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

CEX3232 - HYDRAULICS AND HYDROLOGY

FINAL EXAMINATION 2013/14

Time Allowed : Three Hours Index Number :

Date : 25th August, 2014 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) An open tank, X, discharges water to the atmosphere through a pipeline ABCDE, as shown in Figure 1. All the pipes have a diameter of 2 cm and are all of the same length. The point O is on the free surface of the tank. Assume the water to be inviscid and incompressible.

The elevation of the point B is 1 m below the bottom of the tank while the elevation of point C is 1 m above the bottom of the tank, as shown in the figure. The pipe CD is horizontal. The elevation of the point E, where the water is discharged to the atmosphere, is **h** m below the bottom of the tank.

A, B, C, D and E with respect to the bottom of the tank are shown in the figure. The cross-sectional area of the tank is much larger than the cross-sectional area of the pipes.

a) For the value **h = 1 m** , sketch, on graphs placed one above the other, the variation of the Elevation Head, Velocity Head, Pressure Head and Total Head from O through A, B, C and D, to E. Identify your datum for the elevation and indicate all known values on your graphs.

b) For the value **h = 1 m** , calculate the discharge through the pipeline. State all your assumptions.

c) For the value **h = 1 m** , calculate the lowest pressure in the pipeline.

d) Sketch, on the same graph, the variation of the discharge through the pipeline and the lowest pressure in the pipeline with the value of **h** when **h** varies from 0 m to 3 m . Explain your answer. You do not have to perform any additional calculations.

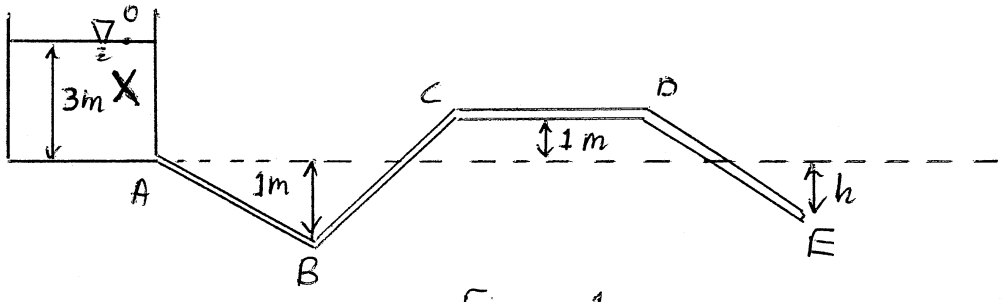

Figure 1

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2) A small reservoir has a constant surface area of 15,000 m^2 . The reservoir discharges water over a rectangular weir that has a length of 20 m and a coefficient of discharge of 0.75 .

Note : The discharge over the rectangular weir is given by the formula $Q=\frac{2}{3}C_d b\sqrt{2g}H^{3/2}$

where $\mathbf{C_d}$ is the coefficient of discharge, **b** the length of the weir and **H** the height of the water level above the weir crest.

At time $t = 0$ a flood flows through the reservoir. The variation of the water level, **H** , in the reservoir with time is given in the Table 2. **H** is the height of the water level above the weir crest.

Time (hours)	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25
H (m)	0.1	0.2	0.5	0.5	0.4	0.3	0.25	0.2	0.15	0.1

Table 2

a) Explain, using a neat figure, what a flood hydrograph is.

b) Calculate the base flow for this flood. Explain your answer.

c) Use the principle of conservation of mass to obtain a relationship between the inflow to the reservoir, $\mathbf{Q_{in}}$, the outflow from the reservoir, $\mathbf{Q_{out}}$ and the rate of change of the water level, **H** , of the reservoir.

d) Use the relationship derived in section c) to show that the water level of the reservoir is a maximum when the inflow is equal to the outflow.

e) Use the relationship derived in section c) to estimate the inflow to the reservoir at the time $t = 0.25$ hours . Explain your answer.

f) Explain, using a sketch of the inflow and outflow hydrographs, the effect of a reservoir on a flood flow. You do not have to calculate the hydrographs.

3) A horizontal pipe, of diameter 5 cm, discharges water to the atmosphere through a nozzle, AB, as shown in Figure 3. The inlet diameter of the nozzle is 5 cm while the outlet diameter is 1 cm . A simple water manometer is fixed to the pipe just upstream of the nozzle, as shown in the figure. The density of water is 1000 kg/m^3 .

When the average velocity of the water in the pipe is 0.5 m/s , the horizontal force on the nozzle is found to be 7 N in the flow direction (i.e. to the right).

a) Calculate the level of water in the manometer tube. Explain your answer.

b) Calculate the rate of energy loss in the nozzle.

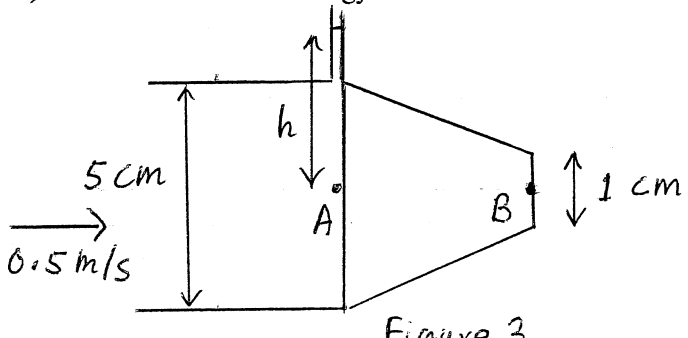

Figure 3

PART B

Answer **any two** questions

4) A student plans to use the apparatus shown in Figure 4 to estimate the friction factor of a pipe. Simple manometers are connected to points A and B on the pipe as shown and the discharge is collected in a tank of uniform cross-section. The measurements to be taken are the heights of the water levels in the manometers and the time taken for the water level in the tank to change by a certain value.

a) Explain how these measurements can be used to estimate the friction factor of the pipe. Identify the other values that should be known and state any equations that will be used.

b) Obtain an expression relating the relative error ($\delta f/f$) in the estimate of the friction factor to the relative error in the measurements of the heights of the water levels in the manometers and the time taken for the water level in the tank to change by a certain value. Explain your answer. You can assume that all the other values are known exactly.

c) Use your result in section b) to suggest how the relative error ($\delta f/f$) in the estimate of the friction factor can be minimized.

d) Sketch the Moody Diagram. Identify and define the parameters on the two axes of the diagram. Identify the regions in the diagram that correspond to Laminar Flow, Transitional Flow, Smooth Turbulent Flow and Fully Rough Turbulent flow.

e) Explain why a logarithmic scale is used for the Moody Diagram.

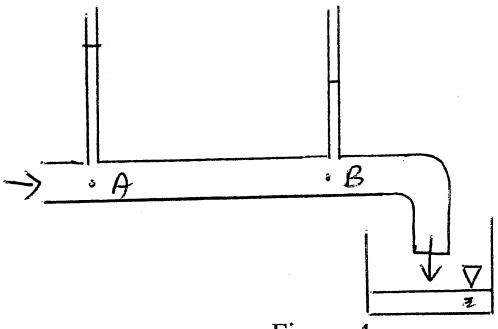

Figure 4

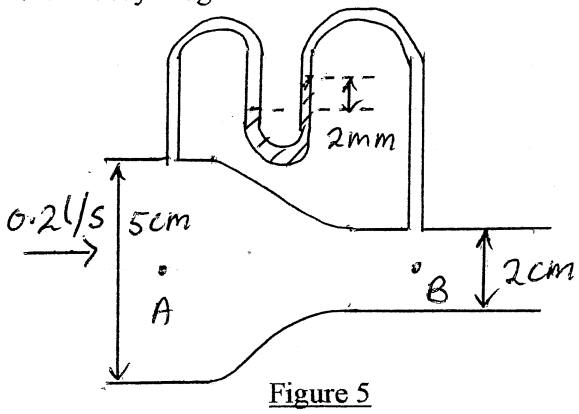

Figure 5

5) A horizontal pipe has a smooth change in diameter, from 5 cm to 2 cm, between points A and B as shown in Figure 5. A U-tube mercury manometer is connected between A and B. When a discharge of 0.2 litres/second flows from A to B the level difference in the mercury manometer is 2 mm , with the lower level shown in the side connected to the point A, as shown in the figure. The density of mercury is 13,600 kg/m^3 and the density of water is 1000 kg/m^3.

a) Obtain, from first principles, the pressure difference between A and B. You should not use any equation that you have memorized.

b) Calculate the head loss between A and B. Explain your answer.

c) When the same discharge flows from B to A the head loss is found to be twice the value when the flow is from A to B. Explain this difference.

d) Calculate the level difference in the mercury manometer when the same discharge flows from B to A. Which side of the manometer has the higher reading?

6) a) What is meant by the term "head" used in Hydraulics?

b) Explain, using a neat figure, how a centrifugal pump works.

c) Describe how you would obtain the variation of the pump head and the pump efficiency with the pump discharge for a given centrifugal pump. Provide neat sketches of the apparatus you would use and give a clear explanation of the method. Explain clearly what quantities are measured and what quantities are calculated from these measurements.

d) Sketch the curves that you would expect to obtain from such an experiment.

7) A long straight open channel has a trapezoidal cross-section, as shown in Figure 7. The bottom width of the channel is 0.5 m and the angle of the side slopes is 45 degrees. The slope of the channel bed is 0.001 . When a certain constant discharge is flowing in this channel the flow depth is found to be 0.5 m at every point in the channel.

A student uses the dilution method to measure the discharge in the channel. In this method a salt solution is introduced into the flow at the upstream end of the channel and the concentration of salt in the channel is measured at the downstream end. The concentration of the solution is 100 g/l and it is introduced at a rate of 0.1 l/s . The concentration of salt in the flow at the downstream end of the channel is found to be 31 mg/l . The flux of salt in the water can be found by multiplying the concentration by the discharge. It is assumed that the water in the channel at the upstream end does not contain any salt.

a) Explain, using examples and neat figures, the difference between steady flow and uniform flow.

b) Apply the principle of conservation of mass for salt and estimate the discharge in the channel. State all your assumptions.

c) Estimate the Manning's coefficient of the channel. Explain your answer.

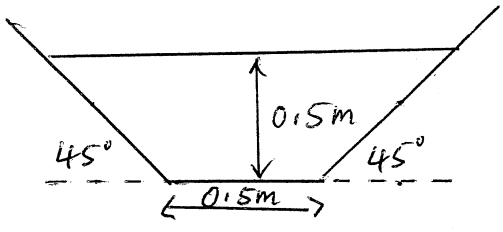

Figure 7

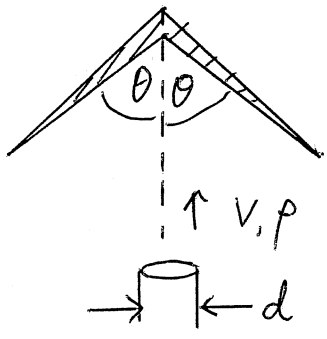

Figure 8

8) The cross-section of a conical target is shown in Figure 8. A vertical jet of water is directed to the inner surface of this target, as shown in Figure 8.

a) Explain how you would obtain an experimental measurement of the force exerted by this jet on the target. Use neat sketches of the apparatus you would use and provide a clear explanation of the method.

b) Derive a theoretical expression that you could use to calculate the force exerted by this jet on the target. State all your assumptions.