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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

CEX 3232 - HYDRAULICS AND HYDROLOGY

FINAL EXAMINATION 2009/2010

Time Allowed : Three Hours *Index No.*

Date : 22nd March, 2010. Time : 1400 - 1700

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 is discharged to the atmosphere from a Tank, X, through a pipeline ABCDEFG, as shown in Figure 1. All the pipes have a diameter of 10 cm and a friction factor of 0.01 . A valve, V , is situated between E and F, as shown in the figure. The valve is fully open and has a loss coefficient of 0.15 .

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 X, to G.

b) Calculate the discharge through the pipeline. Assume reasonable values for any parameters not given and state all your assumptions.

c) Calculate the lowest pressure in the pipeline.

The handle of the valve is now turned until the discharge is reduced to <u>25% of the original value</u>.

d) Sketch, on the same graph, the variation of the Pressure Head from O to G <u>before and after</u> the handle of the valve is turned. Explain your answer.

e) Calculate the loss coefficient of the valve after handle is turned.

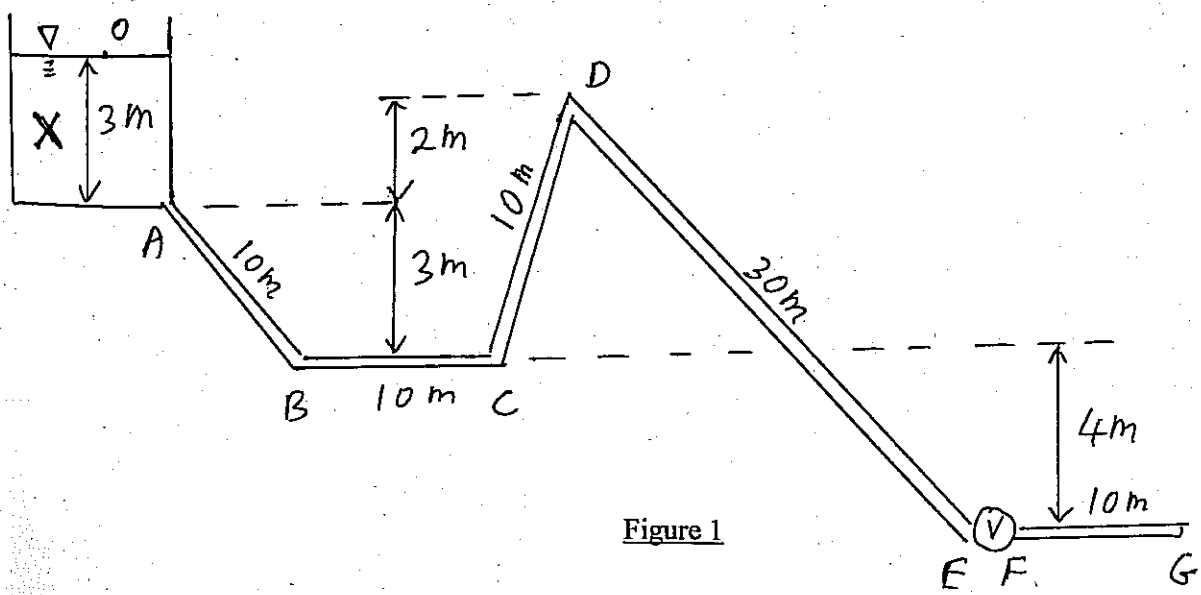

Figure 1

2) A pipe has a section ABC, which has a U-shaped bend in it, is kept in a vertical plane as shown in Figure 2. The pipe has a uniform diameter of 5 cm and the length along the pipe from A to B is 120 cm . A U-tube mercury manometer is connected to A and B, while a simple water manometer is connected to B, as shown in the figure. A and B are at the same horizontal level.

When water flows steadily at a certain rate in the pipe, the mercury levels in the U-tube mercury manometer are as shown in the figure. The difference in the mercury levels is 8 mm, while the water level in the water manometer is 25 cm above the level of B. The rate of energy loss in the flow through this pipe section is found to be 2 W .

(The density of water = 1000 kg/m^3 and the density of mercury = 13,600 kg/m^3)

a) In what direction is the water flowing? Explain your answer.

b) Calculate the discharge through the pipe section ABC.

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

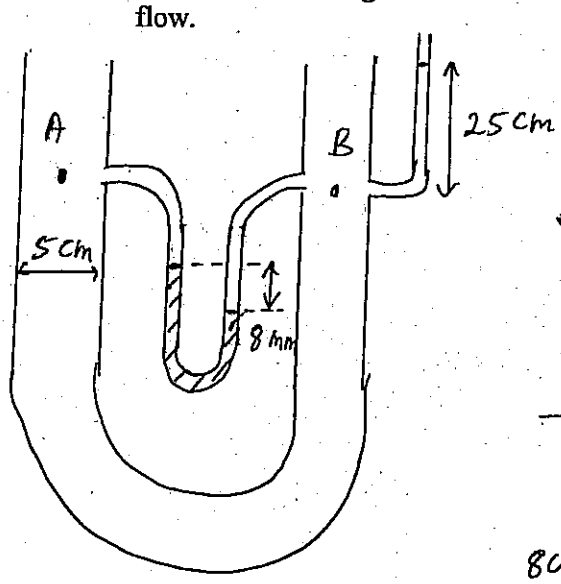

Figure 2

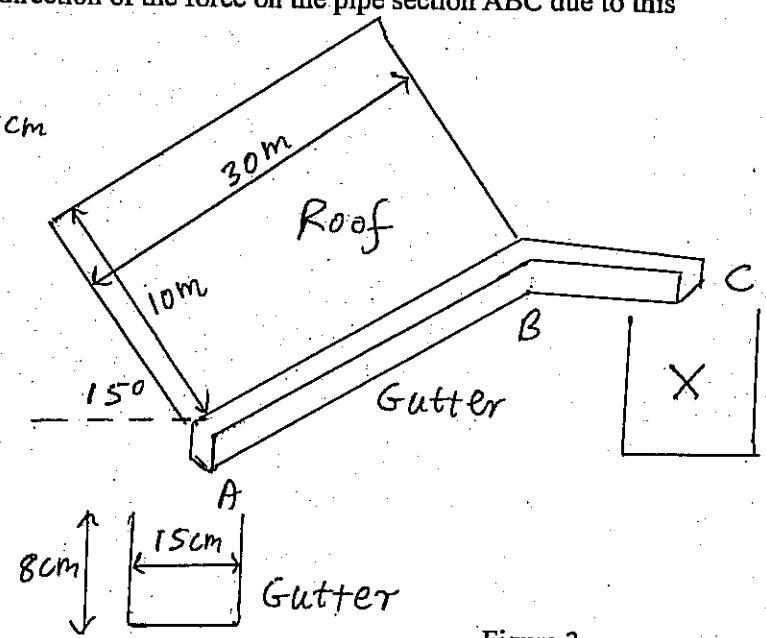

Figure 3

3) The roof of a building is drained by a gutter, ABC to a water tank, as shown in Figure 3. The roof is at an angle of 15 degrees to the horizontal and the dimensions of the roof are shown in the figure. The gutter has a rectangular cross-section, with a width of 15 cm and a height 8 cm. The slope of the gutter is 0.015 and the Manning's coefficient of the gutter is 0.01 .

On a certain day the roof is dry in the morning and the tank is empty. It begins to rain at 1200. The rainfall lasts for 30 minutes at a constant intensity. The total volume collected in the tank as a result of this rainfall is 7000 litres .

a) Sketch the variation of the discharge in the gutter at B with time. Explain your answer.

b) Estimate the intensity of this rainfall. Assume reasonable values for any parameter that is not given and explain your answer.

c) Estimate the maximum intensity of rainfall for which the gutter will not overflow. State your assumptions and explain your answer.

PART B

Answer all **any two** questions

4) A conical tank discharges water through a small hole in its base, as shown in Figure 4. The semi-vertex angle of the cone is 45 degrees and the hole has a diameter of **d** as shown in the figure. At a certain time **t** the water level in the tank is **h(t)** as shown.

a) State the principle of conservation of mass for a fluid control volume.

b) Obtain an expression for the rate of change of the water level in the tank. State all your assumptions.

c) Obtain an expression for the time **t** taken for the water level to fall from a level $\mathbf{h = H}$ to a level $\mathbf{h = H/2}$.

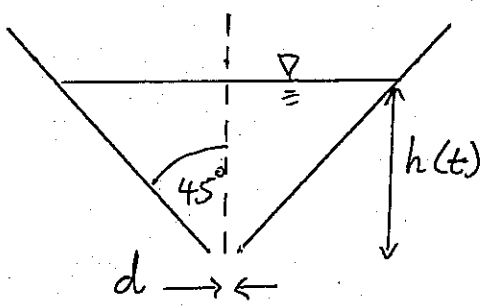

Figure 4

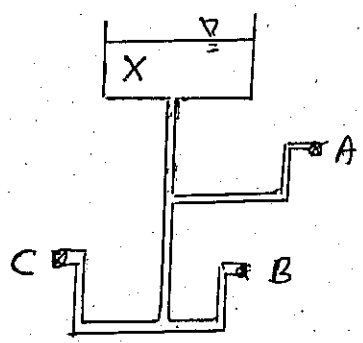

Figure 5

5) Water is supplied from Tank X to three taps, A, B and C, as shown in Figure 5. Tap A is on the first floor while Taps B and C are on the ground floor.

a) If the elevation differences between the water level in the tank and Taps A, B and C and the properties (lengths, diameters, friction factors etc.) of all the pipes are given, explain in detail how you would calculate the discharge from Tank X when Taps B and C are open but Tap A is closed.

b) A house has three taps supplied from an overhead tank as shown in Figure 5. It is found that there is no discharge from Tap A when all three taps are fully opened. Explain how this can happen.

c) What changes would you suggest to the water supply system in this house to solve this problem?

6) a) Explain what is meant by "calibration" of an instrument used for measurement.

b) Explain, using a neat diagram, what a domestic water meter is used for and how it works.

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

d) Explain, using a neat diagram, what a pitot-static tube is used for.

e) Derive a relationship between what is observed in a pitot-static tube and the quantity that is measured using a pitot-static tube.

7) A centrifugal pump is used to pump water from Reservoir X to Tank Y, as shown in F
7. The pipeline AB has a length of 500 m , a diameter of 50 mm and a friction factor of
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.

The rate of change of the water level in tank Y is observed while the tank is being filled.
observed that the rate of change of the water level decreases as the water level increases.
rate of change of the water level in Tank Y is 0.2 mm/s when the water level in Tank Y
1 m. The maximum water level reached is 10 m above the bottom of Tank Y.

a) Explain why the rate of change of the water level in Tank Y decreases as the water lev
increases.

b) Explain why the water level in Tank Y reaches a maximum value.

c) Using the given information calculate two points on the characteristic curve for the pu
(i.e. the pairs of values of pump head and pump discharge that you would obtain from a p
test). Explain your answer.

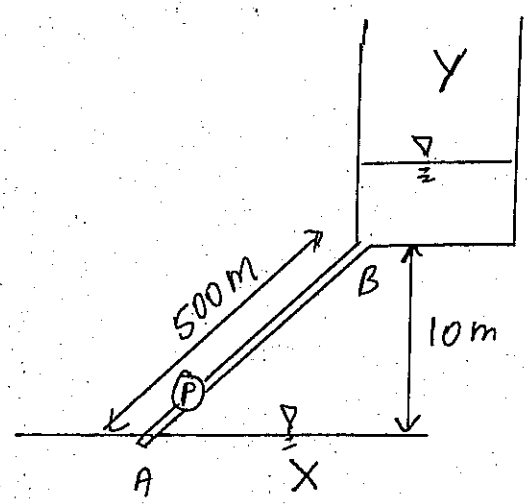

Figure 7

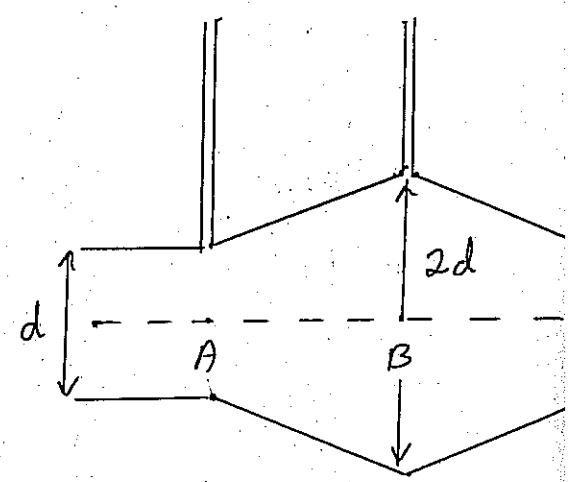

Figure 8

8) A student plans to measure the discharge in a pipeline by using the instrument shown
Figure 8. The instrument consists of an expanding pipe section AB – where the diameter
increases from the pipe diameter **d** to a value of **2d** . The expanding section is followed
a contracting pipe section BC – where the diameter reduces back to the pipe diameter **d** ,
shown in the figure. Simple water manometers are connected at A and B as shown. The
student plans to measure the difference in the water levels in the manometers when water
flowing through the instrument.

a) Which manometer will have a higher water level when water flows through the instrum

b) Derive a relationship between the difference in the water levels in the manometers and
discharge through the instrument. State all your assumptions.

c) Suggest improvements to the design of this instrument. Explain your answer.