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 2010/11

Time Allowed : Three Hours

Date : 21st March, 2011 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 pumped from Tank X to Tank Y using a centrifugal pump, P, and a pipeline ABCDEFGH, as shown in Figure 1. A valve, V, is placed between F and G, as shown in the figure. All the pipes have a diameter of 2 cm and a friction factor of 0.01 . The lengths of the pipes and the differences in elevation are shown in the figure. The valve is fully open and has a loss coefficient of 0.1 in that position. The pump head is 5 m .

a) Sketch, on graphs drawn 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 ABCDEFGH to P, a point on the free surface of Tank Y.

b) Calculate the discharge in the pipeline. State all your assumptions and assume reasonable values for any quantities not given.

When the valve is partially closed so that its loss coefficient is now 2.5, the discharge decreases and the pump head is found to increase.

c) Explain why the pump head increases when the valve is partially closed.

d) Sketch, on the same graph used for section a), the variation of the pressure head after the valve is partially closed. Use a different line type or colour and label the two lines.

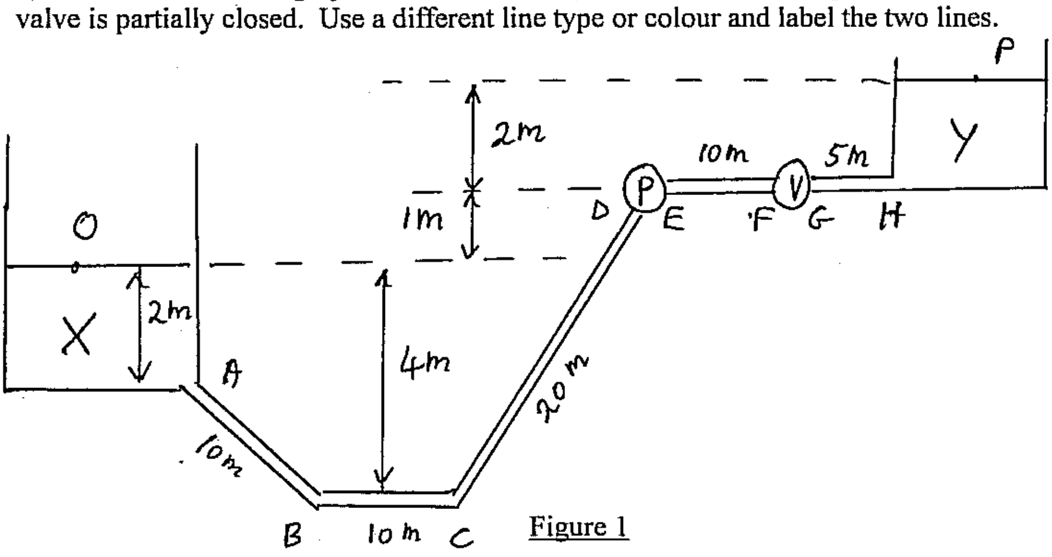

Figure 1

2) The plan view of a component in a pipeline is shown in Figure 2. Water flows into the component at A, where the pipe has a circular cross-section with a diameter of 5 cm. The pipe then divides into two identical smaller pipes, each with a diameter of 2 cm, as shown in the figure. Water is discharged into the atmosphere at B and C through these pipes, as shown in the figure.

The velocity at A is found to be 1 m/s. A simple water manometer is connected to the pipe at A and it is observed that the water level in the manometer rises to a level that is 60 cm above the level of the pipe centerline at A.

a) Calculate the rate of energy loss as the flow passes through this component.

b) Calculate the magnitude and direction of the force exerted on this component as a result of this flow.

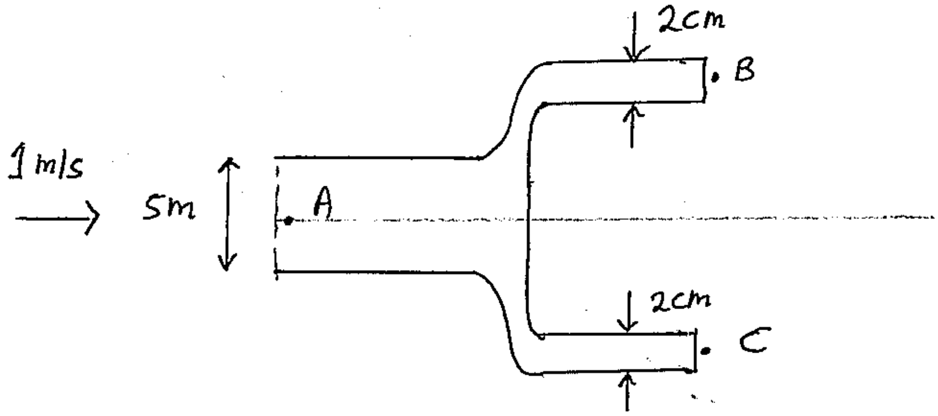

Figure 2

3) a) State Newton's law of viscosity as an equation and identify all the variables in the equation.

b) What are the dimension and the SI unit of the coefficient of dynamic viscosity?

c) The equation $f = \frac{64}{Re}$ is used for laminar flow in a pipe of circular cross-section. Show that the head loss between two points along the pipe is proportional to the average velocity in the pipe under these conditions.

d) Sketch the Moody diagram. Identify and define the variables on the two axes of the diagram. Label the main sections of the diagram.

e) Water flows in a long uniform pipeline of diameter **d**. The head loss between two points spaced a distance **L** apart is found to be **H**. The density of water is ρ and the dynamic viscosity of water is μ. Explain how you would use these values and the Moody diagram to calculate the discharge in the pipeline.

PART B

Answer **any two** questions

4) A student measures the force exerted by a jet of water on a conical target. The student uses the arrangement shown in Figure 4, where the target is directly above a pipe. The jet discharged by the pipe hits the target. 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) One important assumption in the derivation of this equation is that friction between the flow and the target is neglected. Identify the point in your derivation in section a) where this assumption was used.

d) Another important assumption in the derivation of this equation is that the weight of the water in the control volume is neglected. Discuss 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.

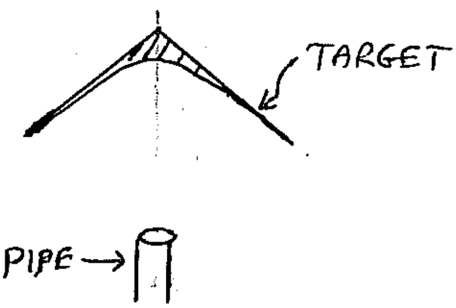

Figure 4

5) a) What is meant by the word "calibration"?

b) Explain how the procedure followed in the laboratory class entitled "Flow Measurement" is related to your answer in section a).

c) Why is it necessary to calibrate a venturimeter?

In the laboratory class entitled "Flow Measurement" the venturimeter was calibrated by introducing a Coefficient of Discharge, C_d, into the theoretical equation for the discharge.

d) Show that the Coefficient of Discharge for a venturimeter is always less than 1 . It may help you to sketch a venturimeter and apply the principle of conservation of energy between two appropriate locations.

6) a) Both rectangular weirs and V-notch weirs are used to measure the discharge in open channels. Explain why V-notch weirs are considered suitable for the measurement of small discharges and why rectangular weirs are considered more suitable for the measurement of large discharges.

b) The theoretical discharge for a V-notch weir is given by the equation

$Q = C_d \left(\frac{-8}{15}\right)\sqrt{2g}Tan\theta H^{5/2}$. Indicate **θ** and **H** on a neat sketch of a V-notch weir.

c) A V-notch weir, with $\theta = 45$, is to be calibrated using the dilution method. In this method a salt solution is introduced into the flow upstream of the weir. The concentration of the solution is 10 g/l and it is introduced at a rate of 0.1 l/s. The concentration of salt in the flow downstream of the weir is found to be 3.2 mg/l. The backwater height from the bottom of the weir for this flow is 0.5 m.

Calculate the value of C_d for the weir. Explain any assumptions you have made.

7) A centrifugal pump is to be used to supply water from Reservoir X to Tank Y, as shown in Figure 7. The water is to be supplied using two pipes, AB and CD, in parallel, as shown in the figure. The pipe AB has a length of 500 m, a diameter of 5 cm and a friction factor of 0.25, while the pipe CD has a diameter of 2 cm and a friction factor of 0.1.

a) Calculate the discharge through the pump. State all your assumptions and explain your answer.

Pump Head (m)	20	16	12	8	4
Discharge (litre/s)	0	1	1.5	1.75	2

Table 7

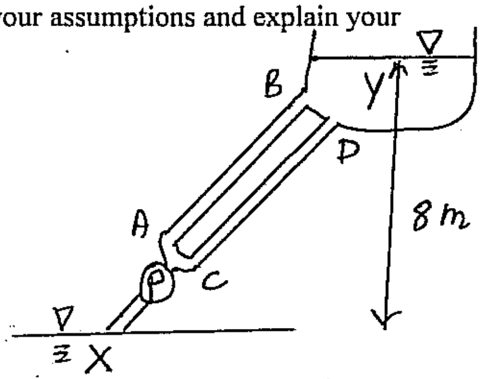

Figure 7

8) a) Define the runoff coefficient when considering the flow of water from a certain area after a certain rainfall.

b) Explain how the runoff coefficient depends on the following factors

i) Slope of the land
ii) Type of soil
iii) Vegetation
iv) Urban development

c) Explain, using neat figure if needed, what is meant by "base flow" in a hydrograph.

A piece of land is drained by an open channel with a rectangular cross-section with a width of 2 m and slope of 0.005. The channel is made of rough cement with a Manning's coefficient of 0.025. The channel is to be designed to carry a peak discharge of 7.5 m^3/s.

d) Calculate the required depth of the channel.