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 2012/13

Time Allowed : Three Hours

Date : 12th August, 2013 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 conical flask has a bottom diameter of 0.5 m, a height of 0.4 m and a base angle of 45°, as shown in Figure 1. The flask has a hole of diameter 3 mm in the side wall, located 0.1 m from the bottom, as shown in the figure.

The flask is empty at a time $t = 0$. At this time water is poured into the flask at a constant flow rate of 10 ml/s .

a) Derive an equation for the variation of the water level in the flask with time – h(t) - for h(t) < 0.1 m .

b) Calculate the time taken for the water level in the flask to reach the level of the hole.

c) Derive a relationship that relates the rate of change of the water level in the flask with time – d(h(t))/dt – to the water level – h(t) - for h(t) > 0.1 m .

d) Show that the water level in the flask reaches a constant level. State your assumptions and explain your answer.

e) Sketch the following on graphs placed one above the other using the same time axis. Mark all the values you can on the axes. Explain your answer.

i) The variation of the water level in the flask
ii) The flow rates into and out of the flask

f) Estimate, as best as you can, the time taken for the water level in the flask to reach a constant level. Explain your answer.

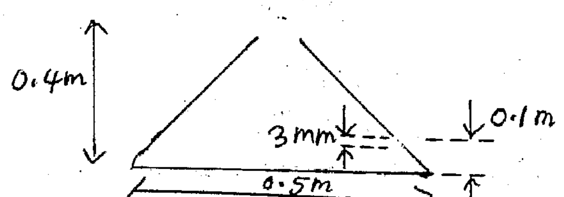

Figure 1

2) A glass pipe with a uniform diameter of 1 cm is bent in the shape of the letter U and placed in a vertical plane as shown in Figure 2. A U-tube mercury (density 13,600 kg/m^3) manometer is connected to the points A and B while a simple water (density 1000 kg/m^3) manometer open to the atmosphere is connected at B. The length of the pipe between A and B is 50 cm.

Water flows steadily into the pipe at A and out at B at a flow rate of 0.1 litres/second. Under these conditions it is observed that the difference in the mercury levels in the U-tube mercury is 2 mm with the mercury level in the tube connected to A being lower than the mercury level in the tube connected to B. The water level in the simple water manometer is found to be 30 mm above the level of B.

a) Explain why Control Volumes are used in the analysis of moving fluids.

b) Explain why the mercury level in the tube connected to A being lower than the mercury level in the tube connected to B.

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

d) Calculate the magnitude and direction of the force on the pipe section AB due to the flow.

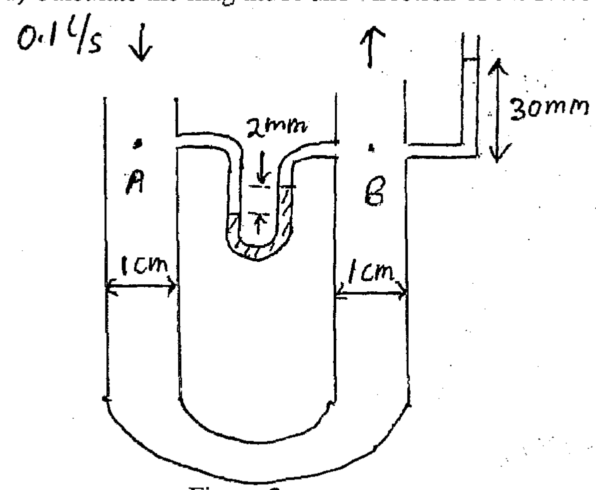

Figure 2

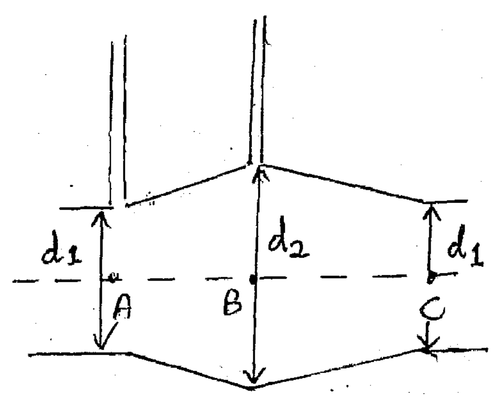

Figure 3

3) A student plans to use the pipe section ABC, shown in Figure 3, as an instrument to measure the discharge of water in a pipeline. The section ABC consists of an expansion section AB where the pipe diameter increases to a maximum at B and a contraction section BC where the pipe diameter decreases to the original diameter at C.

The student plans to attach simple water manometer tubes at A and B as shown in the figure and obtain the discharge by measuring the difference in the water levels in these tubes.

a) Explain what is meant by the term "calibration" with respect to measuring instruments.

b) Which manometer tube will have a higher level when water flows through this instrument? Explain your answer.

c) Obtain a relationship between the difference in manometer levels and the discharge through the instrument. State all your assumptions and explain your answer.

d) Propose, with explanations, how you would improve the design of this instrument.

PART B

Answer **any two** questions

4) A vertical jet of water – of density ρ - is created by discharging water at a flow rate **Q** through a circular pipe of diameter **d** as shown in Figure 4a.

a) Apply the principles of conservation of mass and conservation of momentum to the Control Volume shown in Figure 4b and show the following

i) The velocity of the jet <u>decreases</u> with height above the pipe
ii) The diameter of the jet <u>increases</u> with height above the pipe

A horizontal plate is placed near the pipe as shown in Figure 4c

b) Derive an expression for the force exerted on the plate by the jet. State all your assumptions and explain your answer.

c) What will happen to the force exerted by the jet is the plate is moved <u>upwards</u> a small distance? Explain your answer.

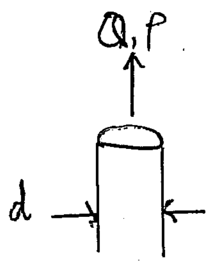

Figure 4a

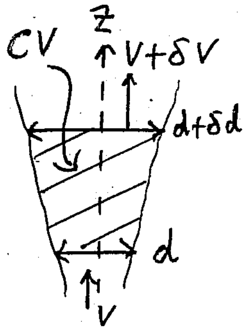

Figure 4b

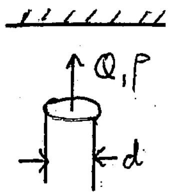

Figure 4c

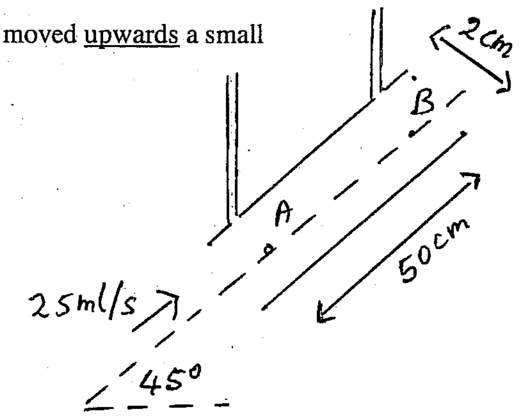

Figure 5

5) Water (density 1000 kg/m^3, dynamic viscosity 0.0015 Pa s) flows steadily <u>up</u> an inclined pipe AB as shown in Figure 5. The diameter of the pipe is 2 cm and the points A and B are 50 cm apart, as shown in the figure. The discharge through the pipe is 25 ml/s . Simple water manometers are connected to points A and B as shown.

The equation **f = 64/Re** is to be used for this problem.

a) Identify and define the parameters f and Re .

b) Identify all the parameters used in the definitions of the parameters f and Re above.

c) Can the equation **f = 64/Re** be used for this problem? Explain your answer.

d) Calculate the difference in the levels of the water manometers at A and B. State which level is higher.

e) Calculate the force on the pipe section AB due to this flow.

6) a) Explain, using a neat figure, how a domestic water meter works.

b) Explain what is meant by "calibration of measuring instruments".

c) Explain why a Coefficient of Discharge is introduced into the equations for the discharge when Venturimeters and Orifice Meters are used.

d) Discuss the differences between the Coefficients of Discharge for a Venturimeter and an Orifice Meter.

e) Compare the use of V-notch weirs and Rectangular weirs in the measurement of the discharge of open channels.

7) a) State the Manning's Equation and identify and define all the variables in it.

b) Under what flow conditions is the Manning's Equation valid?

c) Describe briefly, using a neat diagram, how the Manning's Coefficient can be measured in the laboratory.

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.
Note : You may have to use a trial and error method.

8) Many areas of Colombo are drained by the canal that passes the Open University. The catchment area of the canal at Narahenpita is approximately $75\ km^2$.

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 at Narahenpita 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) Explain what is meant by term "catchment area".

b) Define the runoff coefficient.

c) Sketch the hydrograph and mark the peak flow and the base flow.

d) 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 (2023) what differences would you expect to see in the flood hydograph? Explain your answer with a sketch.