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

CEX3232 - HYDRAULICS AND HYDROLOGY

FINAL EXAMINATION 2016/17

Time Allowed : Three Hours --- Index Number :

Date : 28th November, 2017 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) Water (density 1000 kg/m^3) flows steadily in a uniform pipe with a diameter of 5 cm which is at a 45 degree angle to the horizontal, as shown in Figure 1. Two simple manometers are connected to points A and B, as shown in the figure. The distance between A and B along the pipe is 1 m . When the discharge is 1.75 litres/second the water level in the manometer at A is found to be 75 cm above the level of the pipe at A while water level in the manometer at B is found to be 7 cm above the level of the pipe at B, as shown in the figure.

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

b) Calculate the magnitude and direction of the force acting on the pipe section AB due to the flow of water. State your assumptions and explain your answer.

c) Calculate the shear stress acting on the pipe wall.

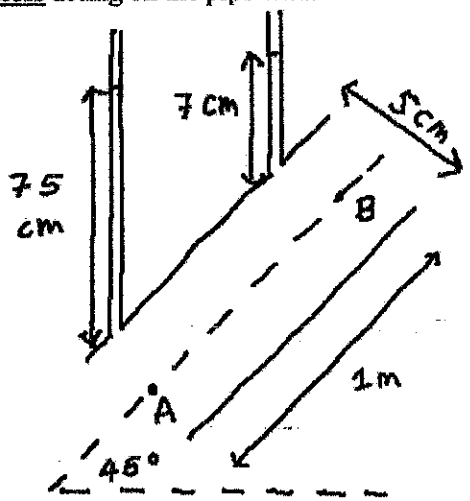

Figure 1

2) a) Explain briefly what is meant by the word "calibration" .

An instrument used to measure the discharge of water, Q, under certain conditions is given by the equation $Q = C_d\left(\frac{8}{15}\right)\sqrt{2g}Tan\theta H^{5/2}$

b) Identify this instrument and explain where it can be used.

c) Identify, using a neat diagram, the quantities H and θ in this equation.

d) Define the term C_d and explain why it is included in the equation.

e) Explain how you would estimate the value of C_d for a given instrument.

A particular instrument has values of $\theta = 45$ degrees and $C_d = 0.85$. The value of the quantity H is found to be 87 mm using a scale that is marked in milli-metres.

f) Calculate the discharge and estimate the possible error in the calculated discharge. Explain your answer.

3) a) State the Bernoulli Equation and list the four conditions under which it is valid.

A cylindrical open tank has a diameter of 1 m and discharges water to the atmosphere at E through a pipeline ABCDE as shown in Figure 3. All the pipes have a diameter of 2.5 cm and the lengths of the pipes are indicated in the figure. At a certain time the water level in the tank is 2 m above the bottom of the tank, as shown in the figure. Neglect all energy losses in your answers to the following questions.

b) 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 the tank, past the points A, B, C and D to E. Identify the elevation datum used.

c) Calculate the discharge through the pipeline at this time. State all your assumptions.

d) Calculate the lowest pressure in the pipeline.

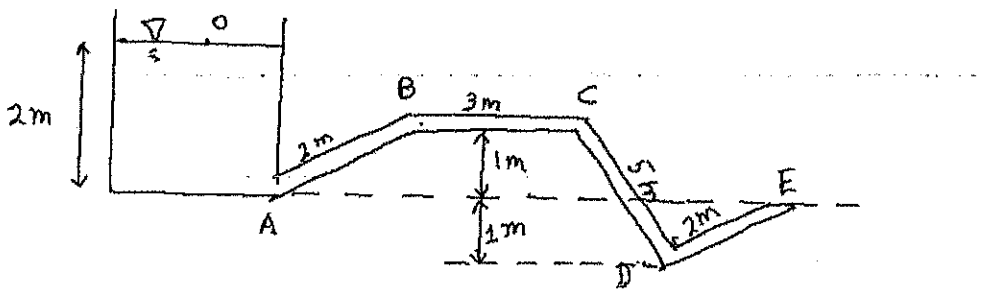

Figure 3

PART B

Answer **any two** questions

4) A steady jet of water (density 1000 kg/m^3) is discharged vertically downward through a pipe of diameter 2 cm as shown in Figure 4. The discharge of the jet is 1 litre/second. The end of the pipe is 1 m above the centre of a flat disk of diameter 0.5 m as shown in the figure.

a) Calculate the force exerted on the disk by the jet of water. State all your assumptions and explain your answer.

b) Discuss briefly how each assumption made in section a) affects the result for the force exerted on the disk.

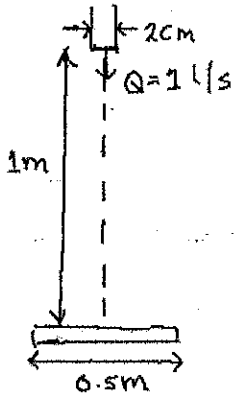

Figure 4

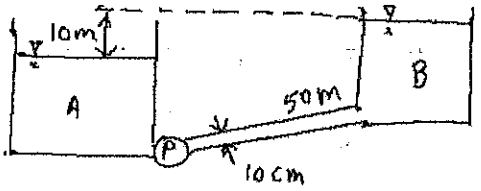

Figure 5

5) A centrifugal pump, P, is used to pump oil between two large open tanks, A and B as shown in Figure 5. The pipeline connecting the tanks is 50 m in length and has a diameter of 10 cm, as shown in the figure. The difference in the elevation of the free surfaces of the tanks is 10 m , as shown in the figure. The density of the oil is 800 kg/m^3 .

The pump operates at a speed of 3000 revolutions per minute and delivers a head of 11 m to the oil flowing through it. The discharge in the pipeline is 4 litres/second . The pump efficiency is 85% .

a) Calculate the output power of the pump.

b) Calculate the torque required to drive the pump under these conditions.

c) Use the principle of conservation of energy (modified Bernoulli equation) to calculate the head lost in friction in the pipe. Assume that pipe friction is the only source of head loss in the system.

d) Calculate the friction factor of the pipe for this flow.

e) Calculate the viscosity of the oil. Assume that the flow of oil is laminar.

6) a) State the Manning's equation.

b) List, identify and define, where necessary, the variables and coefficients in the Manning's equation.

c) What are the conditions under which the Manning's equation can be used?

d) Explain briefly, using a neat diagram, how you would estimate the Manning's coefficient of a uniform open channel in the laboratory.

An open channel of rectangular cross-section has a width of 0.5 m. The channel has a slope of 0.005 and a Manning's coefficient of 0.015 . The channel carries a discharge of 0.1 m^3/s .

e) Calculate the uniform depth of flow in the channel using a trial and error method.

7) A certain catchment has an area of 2.65 km^2 . The catchment is initially in a dry condition and there is no discharge from the catchment. It is known that the runoff coefficient for the catchment in a dry condition is 0.65 .

A rainfall of 25 mm/hour falls uniformly over the catchment for 1 hour. The hydrograph (variation of the discharge of the catchment with time) that results from this rainfall is given in Table 7. Due to an error in the field the discharge at time $t = 2$ was not measured. Note that the time $t = 0$ is the time that the rain started.

Time (hours)	0	1	2	3	4	5	6
Discharge (m^3/s)	0	1	?	3	2	1	0

Table 7

a) Define the runoff coefficient.

b) Estimate the value of the discharge at time $t = 2$ hours. State all your assumptions and explain your answer.

A second rainfall of 25 mm/hour for 1 hour begins over this catchment at time $t = 6$ hours.

c) Sketch, on the same graph, the hydrographs you would expect for the first and second rainfalls.

d) Explain the differences in the hydrographs for the first and second rainfalls in your answer to section c) .

e) Will the runoff coefficients for the first and second rainfalls be the same? Explain your answer.