**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLGY**
**DEPARTMENT OF CIVIL AND WATER ENGINEERING**
**FACULTY OF INDUSTRIAL TECHNOLOGY**
**BACHELOR OF ENGINEERING (HONOURS) DEGREE**
**PART II FIRST SEMESTER EXAMINATION – APRIL 2009**
**HYDRAULICS – TCW 3101**

**INSTRUCTIONS**
Answer any four (4) questions. All questions carry equal marks

Time: 3 hours
Total marks: 100

## QUESTION 1

(a) A large reservoir discharges to the atmosphere via a pipeline. The pipeline is 0.9 m in diameter for the first 300 m, then reduces to 0.6 m diameter for the remaining 550 m. The end of the pipeline is 27 m below the water surface level in the reservoir. The entrance to the pipeline is sharp and the reduction diameter is sudden. Calculate the discharge from the pipeline and evaluate all of the losses. Take friction factors for the first and second pipe to be 0.04 and 0.05 respectively. (10 marks)

(b) A straight pipeline with a horizontal centerline increases in diameter uniformly and symmetrically from $D_1 = 1.3$ m to $D_2 = 2.0$ m. The flow rate through the pipeline is 4.114 $m^3/s$ and the corresponding pressures are $P_1 = 149.573 \times 10^3$ $N/m^2$ and $P_2 = 153.523 \times 10^3$ $N/m^2$. Calculate the force exerted on the pipe expansion by the water, and state clearly in which direction it acts. (8 marks)

(c) A fluid of constant density flows at the rate of 15l/s along a pipeline AB of 100 mm diameter. This pipe branches at B into two pipes BC and BD each of 25 mm diameter and a third pipe BE of 50 mm diameter. The flow rates are such that the flow through BC is 3 times the flow rate through BE and the velocity through BD is 4 m/s. Find the flow rates in the 3 branches BC, BD and BE and the velocities in pipes AB, BC and BE. (7 marks)

## QUESTION 2

(a) Find the proportions of a rectangular channel depth D and width B which will make the discharge a maximum, for a given cross sectional area. (8 marks)

(b) A canal of rectangular cross-section conveys 11.3 $m^3/s$ of water with a velocity of 1.8 m/s. Find the gradient required,
(i) if the proportions are those for maximum discharge,
(ii) If the width is three times the depth. Take Chezy coefficient to be 66. (7 marks)

(c) Water flows down a steep concrete lined rectangular channel 5 m wide at a depth of 0.65 m when the discharge is 19.0 $m^3/s$. At the bottom of the slope the channel becomes horizontal, but is otherwise unchanged. Determine whether a hydraulic jump will form, the energy loss, and approximate dimensions of the jump. (10 marks)

**QUESTION 3**

(a) Derive the equation of gradually varied flow. (5 marks)

(b) A trapezoidal concrete-lined channel has a constant bed slope of 0.0015, a bed width of 3 m and side slopes 1:1. A control gate increases the depth immediately upstream to 4 m when the discharge is 19 m3/s. Compute the water surface profile to depth 5% greater than the uniform flow depth. Take Manning's $n = 0.017$ and $\alpha = 1.1$ (20 marks)

**QUESTION 4**

(a) Outline the differences between pumps and turbines. (5 marks)

(b) A centrifugal pump running at 1000 rev/min gave the following relation between head and discharge:

| **Discharge (m3)/min** | 0 | 4.5 | 9.0 | 13.5 | 18.0 | 22.5 |
|---|---|---|---|---|---|---|
| **Head ( m)** | 22.5 | 22.2 | 21.6 | 19.5 | 14.5 | 0 |

The pump is connected to a 300 mm suction and delivery pipe the total length of which is 69 m and the discharge to atmosphere is 15 m above sump level. The entrance loss is equivalent to an additional 6 m of pipe. Calculate the discharge, taking $\lambda = 0.006$.
If it is required to adjust the flow by regulating the pump speed, estimate the speed to reduce the flow to one-half. (20 marks)

**QUESTION 5**

(a) Water is discharged from a reservoir through a pipe 150 mm diameter and 120 m long. This pipe divides into 2 pipes each of 75 mm diameter. One is 30 m long and discharges into a second reservoir with water level 12 m below the first, the other is 60 m long and discharges into a third reservoir with water level 24 m below the first. Neglecting all losses other than pipe friction, find the discharge into each reservoir. Take $\lambda$ as 0.01. (15 marks)

(b) A 200 mm diameter pipeline, 5000 m long and of effective roughness 0.03 mm delivers water between reservoirs the minimum difference in water level between which is 40m.Taking only friction, entry and velocity head losses into account, determine the steady discharge between the reservoirs.

If the discharge is to be increased to 50l/s without increase in gross head, determine the length of 200 mm diameter pipeline of effective roughness 0.015 mm to be fitted in parallel. Consider only friction losses. (10 marks)