NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF INDUSTRIAL TECHNOLOGY
DEPARTMENT OF CIVIL AND WATER ENGINEERING
BACHELOR OF ENGINEERING (HONOURS) DEGREE
PART III FIRST SEMESTER EXAMINATIONS – JANUARY 2011

HYDRAULICS – TCW 3101

Instructions:
Answer any 4 questions. All questions carry equal marks.

Total marks: 100 *Time: 3 Hours*

QUESTION 1

a. A drainage pump having a tapered suction pipe, discharges water out of a sump. The pipe diameters at the inlet and at the upper end are 1 m and 0.5 m respectively. The free water surface in the sump is 2 m above the center of the inlet and the pipe is laid at a slope 1 (vertical): 4 (along pipeline). The pressure at the top end of the pipe is 0.25 m mercury (density = 13600 kg/m^3, viscosity of water = $1x10^{-3}$ Ns/m^2) below atmosphere and it is known that the loss of head due to friction between the two sections is 1/10 of the velocity head at the top section. Compute the discharge through the pipe, taking a length of 20 m. (10 marks)

b. A pipeline with a constant diameter of 0.3 m turns through an angle of 60^o. The centerline of pipe does not change elevation. The discharge through the pipeline is 0.1 m^3/s of water and the pressure at the bend is 30 m of water. Calculate the magnitude and direction of the resultant force on the pipe.
(15 marks)

QUESTION 2

a. Two reservoirs, the water levels in which are at elevations 180 m and 150 m respectively, are connected by a pipe 3 km long, 600 mm diameter and friction factor 0.00625. The elevation of the ground along the pipeline is given in Table 2a. Assuming a rounded inlet and an abrupt outlet calculate the discharge. Find the maximum depth of the pipeline below ground if the absolute pressure therein is not to fall below 3 m of water. **Table 2a**

Distance (m)	0	150	300	1800	3000
Elevation (m)	175	165	190	140	147

(15 marks)

b. A pipeline 10 km long, 300 mm in diameter and with roughness size 0.03 mm, conveys water from a reservoir (top water level 850 m above datum) to a water treatment plant (inlet water level 700 m above datum). Assuming that the reservoir remains full estimate the discharge, using the Colebrook-White formula and the Moody diagram. (10 marks)

QUESTION 3

a. Derive the general differential equation for gradually varied flows. (5 marks)

b. A trapezoidal channel having a Manning's n = 0.022 with 3.5-m bottom width, side 1: 2, bed slope of 0.012, discharge 40 m^3/s of fresh water from a reservoir. Determine the water surface profile to within 2% of normal depth. (20 marks)

QUESTION 4

a. Differentiate between pumps and turbines (6 marks)

b. An existing pump, having the characteristics shown in Table 4b, is used to pump raw sewage to a treatment plant through a static lift of 20 m. A pipeline 10 km long is to be used. Taking minor losses totaling $10v^2/2g$, pipe roughness of 0.15 mm select a suitable pipe size to achieve a discharge of 60 l/s. Calculate the power consumption. (10 marks)

Table 4b

Discharge (l/s)	0	10	20	30	40	50	60	70
Total head (m)	45	44.7	43.7	42.5	40.6	38.0	35.0	31.0
Overall efficiency (%)	-	35	50	57	60	60	53	40

c. Why is the consideration of cavitation important in pump-pipeline systems design? (2 marks)

d. If the phenomenon of cavitation is observed in a particular pump, with a cavitation parameter = 0.08, operating at sea level and the pump delivers 0.42 m^3/s of water, determine the gauge pressure and the velocity head at the inlet. The dynamic head is 85 m and the suction pipe diameter is 30 cm. (7 marks)

QUESTION 5

a. Given a wide rectangular channel of width 5 m, maximum depth 2 m, discharge 10 m^3/s. The normal depth is 1.25 m. Determine the depth of flow downstream of a section in which the bed rises by 0.2 m over a distance of 1 m. (10 marks)

b. A long rectangular channel 3 m wide carries a discharge of 15 m3/s. The channel slope is 0.004 and the Manning's coefficient 0.01. At a certain point in the channel where the flow reaches the normal depth,

   i. determine the state of flow

ii. if the hydraulic jump occurs, what is the sequent depth at the jump?

iii. estimate the energy loss through the jump.

List of equations

Colebrook-White equation:

$$1/\lambda^{1/2} = -2\log [k/3.7D + 2.51/(Re\ \lambda^{1/2})]$$

Colebrook-White - Darcy-Weisbach equation

$$v = -2(2gDs_f)^{1/2}. \log[k/3.7D + 2.51v/D(2gDs_f)^{1/2}]$$

Hazen-Williams equation

$$v = 0.85C_{HW}R_h^{0.63}S^{0.54}$$