NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF CIVIL AND WATER ENGINEERING

HYDRAULICS

TCW 3101

Main Examinations paper

December 2015

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements:

Examiner's Name: Mrs S. Nhandara

INSTRUCTIONS

1. Answer four questions
2. Each question carries 25 marks

MARK ALLOCATION

QUESTION	MARKS
1	25
2	25
3	25
4	25
5	25
TOTAL	100

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QUESTION 1

a. i. A 450mm concrete lined sewer pipe has a surface width of 300mm. If the gradient is 1 in 200, the normal depth 350mm and the subtended angle ø is 250^{o}. Calculate the quantity of flow. Manning's n is $0.012m^{-1/3}s$. (5 marks)

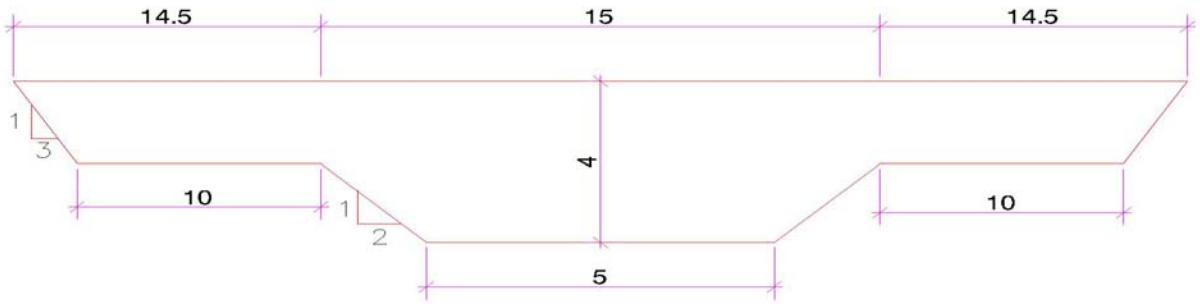
ii. If the quantity of flow is $30m^3/s$. What should be the appropriate pipe diameter of the sewer line (7 marks)

b. The figure below shows the cross-section of a river channel passing through a flood plain. The roughness coefficient of the flood plain and river channel is 0.025 and 0.015 respectively. Bed slope is 0.00125. Determine

i. The discharge of a flood level of 4m (8 marks)

ii. The energy coefficient (5 marks)

[25 marks]



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QUESTION 2

a. A trapezoidal irrigation channel excavated in silty sand having a critical tractive force on the horizontal of $2.4N/m^2$ and an angle of friction 30^o is to be designed to convey a discharge of $10m^3/s$ on a bed slope of 1:10 000. The side slope is 1V:2H, n = 0.02

(6 marks)

b. Determine the dimensions of a trapezoidal channel lined with concrete (k=0.15mm) with side slopes at 45^o to the horizontal and bed slope 1:1000 to discharge $20m^3/s$ of water at 15^0C under uniform flow condition such that the section is the most economic

(5 marks)

c. A circular storm water sewer 1.5m in diameter and effective roughness 0.6mm is laid to a slope of 1:500. Determine the maximum discharge which the sewer will convey under open channel conditions (4 marks)

d. i. At a measured discharge of $40m^3/s$ the depth of uniform flow in a rectangular channel 5m wide and with a bed slope of 1:1000 was 3.05m. Determine Manning's roughness coefficient

Using (a) The Darcy-Weisbach equation together with the Colebrook-White equation and (b) the Manning equation predict the discharge at a depth of 4m (10 marks)

[25 marks]

QUESTION 3

a. Define the term 'critical velocity' and derive an expression for the critical velocity in any channel in terms of the discharge Q, area of cross-section A, and width of water surface B. Hence show that in a rectangular channel the critical depth is 2/3 of the specific energy E and the Froude number Fr for critical depth conditions is unity.

(15 marks)

b. Water flows in a channel of rectangular section with a velocity of 1.5 m/s and a depth of 1.2 m. Determine i. the specific energy of the flow, ii. The critical depth iii. The maximum discharge under critical flow conditions if the channel is 3 m wide.

(10 marks)

[25 marks]

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QUESTION 4

a. i. Outline the advantages of parallel pump arrangement (2 marks)

ii. What are the effects of cavitation and how can it be prevented (4 marks)

b. An axial flow pump lifts water from a large tank at a rate of 15L/s. The measured input power is 8Kw and the pump is operating at an efficiency of 65%. Find the head developed across the pump (5marks)

c. Two identical pumps having the tabulated characteristics are to be installed in a pumping station to deliver sewage to a setting tank through a 200mm uPVC pipeline is 2.5km long. The static lift is 15m. Allowing for minor headloss of $10.0V^2/2g$ and assuming an effective roughness of 0.15mm. Calculate the discharge and power consumption if the pumps were to be connected (a) in parallel (b) in series (14 marks)

Pump characteristics

Discharge (l/s)	0	10	20	30	40
Total head (m)	30	27.5	23.5	17.0	7.5
Overall efficiency (%)	-	44	58	50	18

QUESTION 5

a. Show how the Bernoulli equation is applied to measure flow over a raised hump (5 marks)

b. A sluice gate is discharging water freely (modular flow) under a head of 5m (upstream of the gate) with a gate opening of 1.5m. Compute the discharge rate per unit width of the gate. If the water depth immediately downstream of the gate is 2m(drowned/ non-modular flow) determine the discharge rate (10 marks)

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c. A broad crested weir is to be constructed in a long rectangular channel of mild bed slope for discharge monitoring by single upstream depth measurement. Bed width = 4.0. Discharge measurement range from 3.0m3/s to 20m3/s.

Depth-discharge (uniform flow) rating curve for channel:

Depth (m)	0.5	1,00	1.5	2,00	2.5
Discharge m3/s	3.00	8.15	14.22	20.8	27.7

Select a suitable crest height for the weir (10 marks)

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

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

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