The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX5241 Hydraulic Engineering II**
Academic Year	: 2022/2023
Date	: 21st February 2023
Time	: 1330-1630 hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Seven (7)** questions in **Three (3)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Relevant charts/ codes are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear hand written.
8. Do not use Red colour pen.

Q1. A 4 m wide and 2 m deep rectangular channel has a discharge rate of 15 m^3/s. The width of the channel is reduced to 3.1 m at a downstream location.

a) Find the depth of the water at the contraction and use an E-Y diagram to illustrate the flow conditions in the channel segments. State any assumptions made (Note: $Fr = \frac{v}{\sqrt{gy}}$).

(6 marks)

b) Compute the highest unit discharge, which can be sent through the contraction by altering the contracted width, without affecting the upstream water level. Illustrate the flow situation in the channel sections in an E-Y diagram.

(7 marks)

c) Determine the maximum unit discharge that can be sent through the contraction without affecting the upstream water level by changing the contracted width. Use an E-Y diagram to illustrate the flow situation in the channel sections.

(7 marks)

Q2. Figure Q2 illustrates a 3 m wide rectangular open channel (ABC) with a reach AB having a bed slope of 0.006 and a Manning's coefficient of 0.015, followed by a reach BC with a bed slope of 0.0008 and a Manning's coefficient of 0.020, and ending with a free overfall at C. The flow entering the channel at A is uniform, and the depth of the uniform flow along the length AB of the channel is 0.8 meters.

i) Compute uniform flow depth of the channel stretch BC

(5 marks)

ii) State whether the slopes of the channel reaches AB and BC are mild or steep.

(5 marks)

iii) Sketch the possible water surface profiles for the entire channel.

(4 marks)

iv) If flow velocity at a section X on the channel stretch BC is 1.5 m/s, determine how far upstream or downstream from the section X to a another section on the same channel stretch where the flow velocity is 2.0 m/s (Use step method with a single step). State which is the upstream section. Explain your answer clearly.

(6 marks)

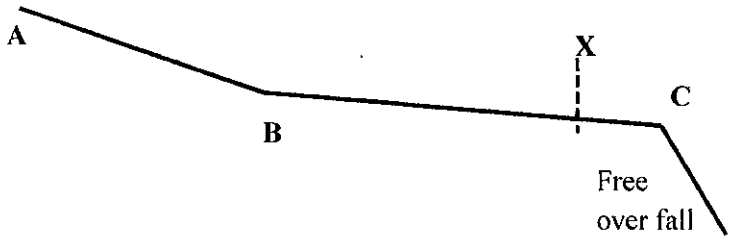

Figure Q2

Q3.

a) Briefly explain what a hydraulic jump is and list three applications.

(5 marks)

b) For a hydraulic jump occurring in a wide rectangular open channel, with usual notation show that, (7 marks)

$$\frac{y_2}{y_1} = \frac{1}{2}[\sqrt{1 + 8Fr^2} - 1]$$

c) Water flows in a rectangular channel at a depth of 0.3 m and a velocity of 19 m/s. If a downstream hump forces a hydraulic jump, what will be the depth and velocity downstream of the jump? Estimate the head loss produced by the jump.

(8 marks)

Q4.

a) Briefly explain what is critical shear stress in sediment transport.

(6 marks)

b) An irrigation channel is required to be constructed from reservoir to an agricultural land on a slope of 1:1200 through an area consisting of fine gravel (d = 8 mm) and $\rho s/\rho = 2.65$. Find the minimum width for the channel if it needs to carry 25 m^3/s of clear water. Maximum allowable shear stress (T_{ocr}) for no erosion over find gravel was found to be 7.7 Pa. State any assumptions made.

(14 marks)

Note: Manning's roughness coefficient (n) = $0.039.d^{1/6}$ where d is the grain diameter

Q5.

a) Briefly discuss the importance of ground water exploration and briefly explain two sub surface investigation methods.

(4 marks)

b) Discuss three factors controlling porosity.

(6 marks)

c) Briefly explain the relationship between specific yield, specific retention and porosity with aid of a graph.

(5 marks)

d) Water was extracted from an unconfined aquifer with a horizontal area of 20 m^2 and a specific yield of 0.15 for an industrial project. if groundwater extraction resulted in a 2 m reduction in the water table. Calculate the amount of water that has been drawn from the aquifer.

(5 marks)

Q6.

a) Derive the equation for steady, radial flow to a well in a confined aquifer.

(10 marks)

b) A 25 m thick confined sandstone aquifer is to be developed as an industrial water supply from a borehole that fully penetrates it. The newly drilled borehole is subjected to test pumping until steady-state conditions are reached. At the steady state, the measured groundwater levels at two observation boreholes situated 100 m and 500 m from the pumping borehole are 58 m and 60 m above the top of the aquifer, respectively.

The pumped borehole produced a flow of 16 liters per second (L/s) during the test. Calculate the transmissivity and hydraulic conductivity of the sandstone aquifer using the pumping test data. State any assumptions made in your calculation.

(10 marks)

Q7.

(a) Using Darcy's Law derive an equation describing the shape of phreatic surface between two long parallel canals completely penetrating an unconfined aquifer with a continuous recharge occurring uniformly over the aquifer. State any assumptions made.

(10 marks)

(b) The distance between two long parallel canals completely penetrating an unconfined aquifer is 100 m. The water levels in the canals are 4 m above the bottom of the aquifer and the aquifer receives a continuous recharge of 2×10^{-6} $m^3/s/m^2$ uniformly over the surface of the aquifer. The hydraulic conductivity of the unconfined aquifer is 3×10^{-4} m/s. Assume the conditions have reached steady state.

i. Find the maximum depth of the phreatic surface.

(5 marks)

ii. Calculate the flow rate from the unconfined aquifer to the canals.

(5 marks)