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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	**: CVX 4240 Hydraulic Engineering I**
Academic Year	: 2020/21
Date	: 1st February 2022
Time	: 09:30-12:30hrs
Duration	**: 3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **FIVE (5)** questions on **Five (5)** pages.
3. Answer **ALL FIVE (05)** questions. Each question carries 20 Marks.
4. Answer for each question should commence from a **new page.**
5. **Clearly mention any assumptions** made for calculations.
6. This is a **Closed Book Examination**.
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.
9. An electronic non-programmable calculator may be used.
10. Take,

    Density of water = $1000\ kg/m^3$

    Acceleration due to gravity = $9.81\ m/s^2$

    Dynamic viscosity of water = $1.0 \times 10^{-3}\ kg.m^{-1}.s^{-1}$

[Q1]

(i) Briefly explain the ***geometric similarity*** and the ***kinematic similarity***. [05 Marks]

(ii) The power (P) required to rotate an agitator, which is installed in a circular tank of a waste water treatment plant is a function of the diameter of the agitator (D), the rotational speed of the agitator (rotations per unit time) (N), the dynamic viscosity of the fluid (μ), and the density of the fluid (ρ). Use the Buckingham's Π $theorem$ to develop a formula for power using nondimensional parameters. [10 Marks]

(iii) A model of the above agitator tank system needs to be designed to simulate its performance. 5 kW (kilo-Watts) of power is required to agitate the fluid in the prototype. The rotational speed and the diameter of the agitator in the prototype are 1 rotation per minute and 10 m, respectively. If a 1:5 scaled-down model is used for this purpose and the agitator's rotational speed of the model is as same as the prototype, considering the geometric similarity, **determine the power requirement for the model**. Assume that the same fluid is used for both the prototype and the model.

[05 Marks]

[Q2] A water distribution system in a factory is shown in **Figure Q2**. Water is supplied to the network at point 'A' and is taken out at points 'B', 'C', and 'D'. Determine the flow rate in each pipe using the quantity balancing method. **(the error (ΔQ) in each loop should be less than 0.5 m^3/s or the calculations should be performed up to three iterations)** [20 Marks]

Take, $Q_B = 50\ m^3/s$, $Q_C = 70\ m^3/s$, $Q_D = 30\ m^3/s$

Additional information,

$$\Delta Q = \frac{\sum K_i Q_i^2}{2\sum |K_i Q_i|}$$

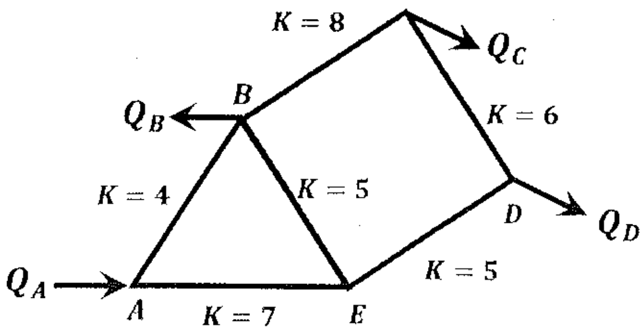


Figure Q2

[Q3]

(i) Briefly describe what is meant by the ***Energy grade line (EGL)*** and ***Hydraulic grade line (HGL)*** in open channel flow? Clearly show them in a sketch of a horizontal profile of an open channel flow. [06 Marks]

(ii) **Figure Q3** shows a sketch of a horizontal profile of an open channel flow. Under uniform flow conditions in an open channel, using Bernoulli equation, **prove that,**

(a) The difference in elevation is equal to the energy lost due to friction.

(b) The total head at point 1 $(H_1) = \frac{V_1^2}{2g} + (Z_1 + h_1)$. [06 Marks]

Where,

V – *Velocity*, Z –*Datum head*, g –*Acceleration due to gravity*,

h_1 – *Depth to the point 1 from the water surface*

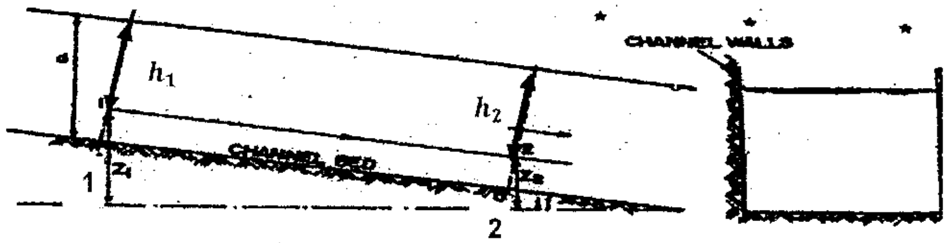


Figure Q3

(iii) A 15 m wide and 6 km long rectangular channel is constructed to convey water between two reservoirs. The channel bed slope is 1:1500 and it conveys 40 m^3/s of water at a depth of 1.5 m.

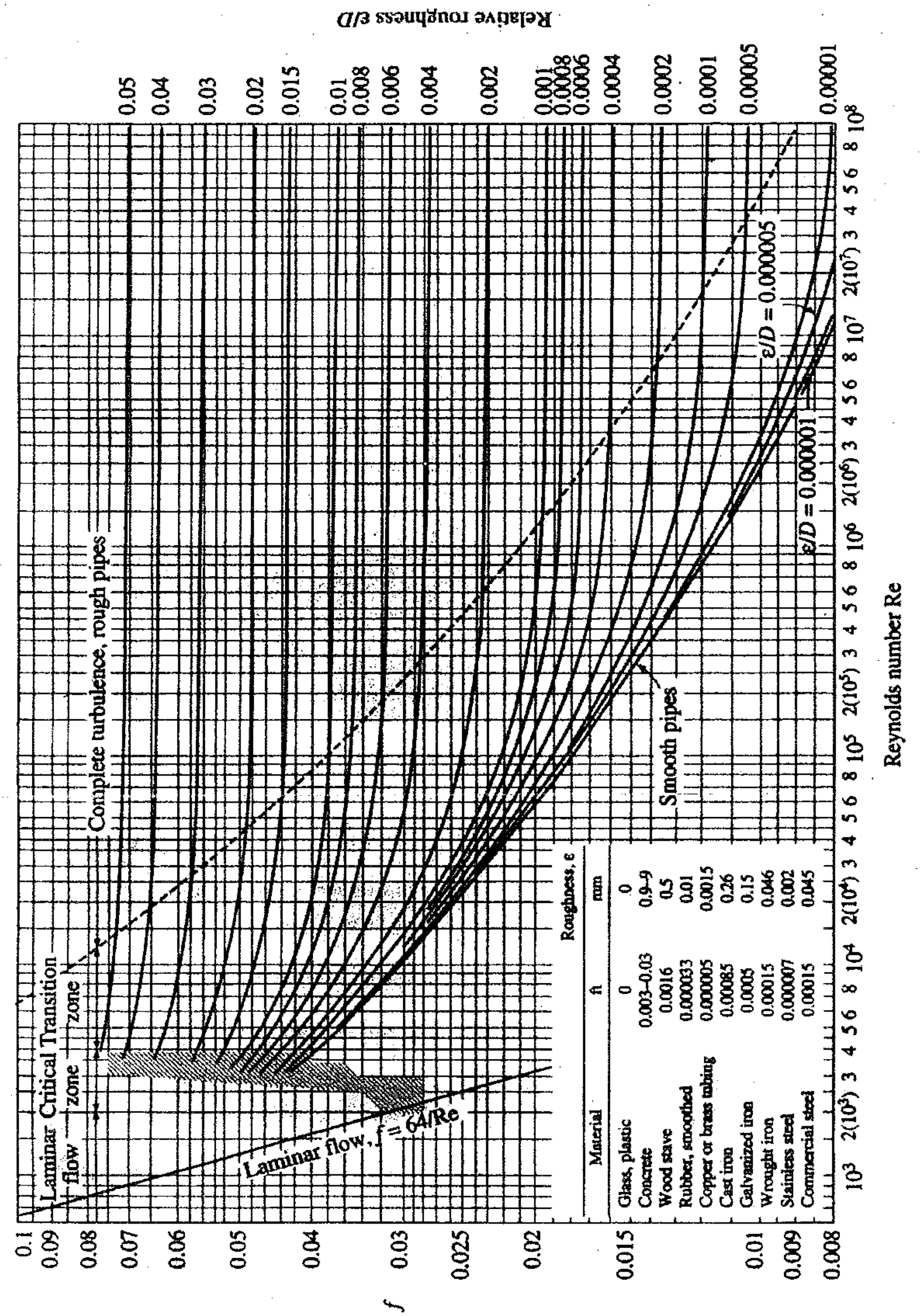
(a) What is the total head loss due to friction along the channel?

(b) The maximum water depth of the channel for safe operation is 2.2 m. Considering the Chezy's formula for this channel, determine the maximum discharge in the channel. [08 Marks]

Additional information,

Chezy's formula $V = C\sqrt{mi}$

Chezy's coefficient (C) is related to depth of flow (d) and roughness of the channel (k) by, $C = 5.75\sqrt{g}\ log_{10}(13.2d/k)$



Moody's Diagram