

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



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: CVX 4240 Hydraulic Engineering I
Academic Year	: 2024/25
Date	: 26 th February 2026
Time	: 13:30-16:30hrs
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering questions.
2. This question paper consists of **FIVE (5)** questions on **Five (5)** pages.
3. Answer **ANY FOUR (04)** questions. Each question carries **25 Marks**.
4. The answer to each question should commence from a **new page**.
5. **Mention any assumptions** made for calculations.
6. This is a **Closed Book Examination**.
7. Answers should be in clear handwriting.
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 = $1.0 \times 10^{-3} \text{ kg.m}^{-1}.\text{s}^{-1}$

[Q1]

- (i) What are the three primary purposes of dimensional analysis? [6 Marks]
- (ii) Experimental investigation showed that the inside and outside pressure difference (ΔP) of a soap bubble is proportional to the soap bubble radius (R), and the surface tension (σ_s) of the soap film. Establish a relationship for the pressure difference (ΔP) using **Buckingham's Pi Theorem**. [13 Marks]
- (iii) What is meant by "Dimensional homogeneity"? [3 Marks]
- (iv) Briefly describe the **dynamic similarity**. [3 Marks]

[Q2] **Figure Q2** shows a schematic diagram of a water distribution system. Water enters the network at points A and D, while water is withdrawn at points B and C. The frictional head loss in each pipe will be $h_f = KQ^2$. Determine the flow rate in each pipe using the **quantity balancing method**. Perform calculations until the error is less than 0.05 ($\Delta Q < 0.05$). [25 Marks]

For the initial iteration take, $Q_{AB} = 40 \text{ m}^3/\text{s}$ and $Q_{DC} = 25 \text{ m}^3/\text{s}$

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

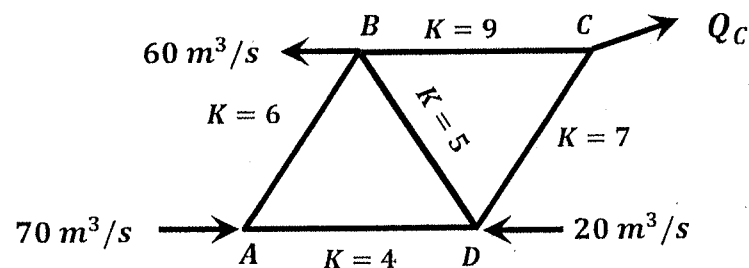


Figure Q2

[Q3]

- (i) Find the **wetted perimeter (p)** and the **hydraulic mean depth (m)** of a trapezoidal open channel section shown in **Figure Q3(a)**. [8 Marks]

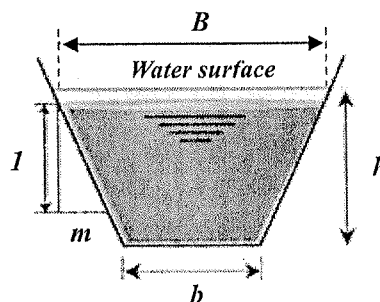


Figure Q3(a)

- (ii) **Figure Q3(b)** shows a rectangular channel conveying water from A to B. The channel is 7 m wide, and the total length is 18 km. As shown in **Figure Q3(b)**, the channel bed slope changes at location C. The channel bed slopes in the AC and CB are 1:1500 and 1:2000, respectively. The flowrate in the AC and CB is $25 \text{ m}^3/\text{s}$ at a depth of 1.5 m. (Assume the water depths of AC and CB channels are equal)

(a) Calculate the total head loss due to friction along the channel (from A to B).

[2 Marks]

(b) Determine the Chezy's coefficients (C) for AC and CB.

[5 Marks]

(c) Calculate the roughness values (k) of AC and CB channel sections.

[5 Marks]

(d) The maximum allowable water depth in the channel (for safe operation) is 2.0 m. Using Chezy's formula, determine the **maximum discharge in channel AB**.

[5 Marks]

Additional information,

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

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

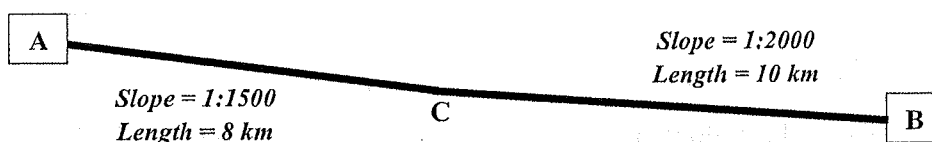


Figure Q3(b)

[Q4]

- (i) Give two examples for each of the following machines.

- (a) Reversible pumps
(b) Non-reversible pumps

[4 Marks]

- (ii) Briefly describe the following.

- (a) Impulse turbines
(b) Reaction turbines

[6 Marks]

- (iii) **Figure Q4** shows a sluice gate of a reservoir and water is discharged through a 7.5 m wide channel. As shown in **Figure Q4**, water passing under the gate forms a hydraulic jump. If the flowrate of the channel needs to be maintained at $10.5 \text{ m}^3/\text{s}$, answer the following questions from (a) to (e). Assume rectangular cross-section at the sluice gate and in the channel.

(a) What is the Froude number at the sluice gate?

[3 Marks]

(b) What is the water depth after the hydraulic jump (y_2)?

[4 Marks]

- (c) What is the Froude number after the hydraulic jump? [3 Marks]
 (d) What is the height of the hydraulic jump? [2 Marks]
 (e) How much is the energy dissipation due to the hydraulic jump? [3 Marks]

Additional information:

$$\frac{y_2}{y_1} = \frac{1}{2} \left(\sqrt{1 + 8Fr_1^2} - 1 \right)$$

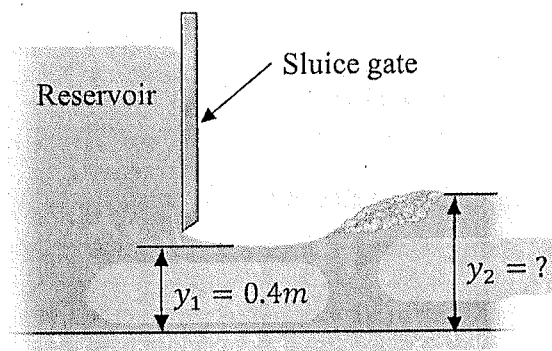
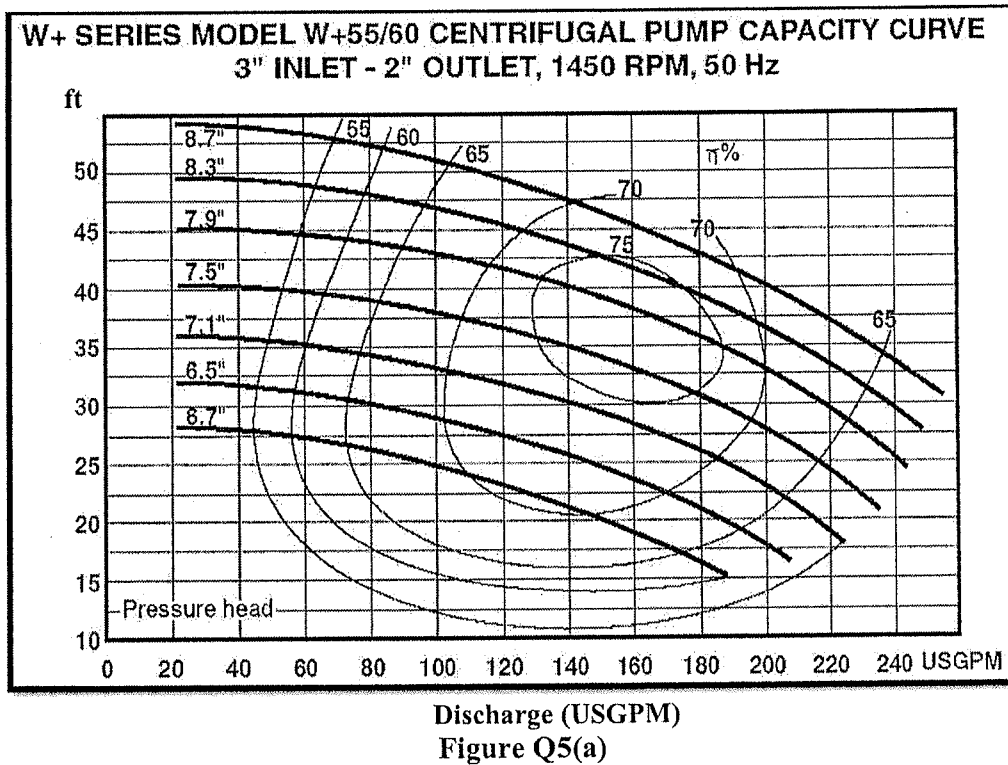


Figure Q4

[Q5]

- (i) What is meant by the shut-off head of a centrifugal pump? [3 Marks]
 (ii) Briefly describe the cavitation in hydraulic machinery. [3 Marks]
 (iii) Answer the following questions based on the performance curve of a centrifugal pump shown in **Figure Q5(a)**.
 (a) If the required pressure head is 35 ft (feet) and the impeller diameter is 7.5" (inches), what is the water discharge of the pump? [3 Marks]
 (b) What is the minimum level of efficiency when the pump is operating under the conditions stated in [Q5] (iii) (a). [3 Marks]
 (c) If the required pressure head is 37 ft, then what are the impeller diameters suitable for pumping water at a rate of 180 USGPM? [4 Marks]

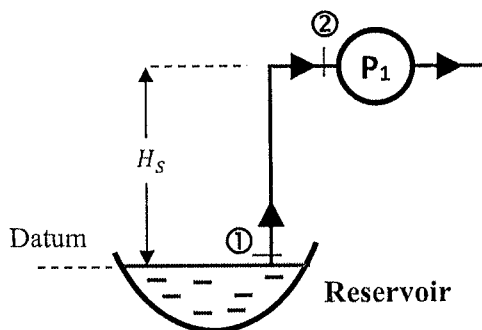


- (iv) As shown in **Figure 5(b)**, a water pump (P_1) draws water from a reservoir and discharges to a pipeline. The suction head of the pump is H_s . Point ① is located at the water surface level of the reservoir and point ② is located at the pump inlet.

Show that,

$$\text{Suction Head } (H_s) < \frac{P_a}{\rho g} - \frac{P_v}{\rho g} - \frac{V_2^2}{2g} - h_{fs}$$

[9 Marks]



Where,

P_a – Atmospheric pressure

P_v – Vapor pressure of water

h_{fs} – Friction loss in the pipe of the suction side

V_2 – Velocity at pump inlet

ρ – Density of water

g – Acceleration due to gravity

– End of Paper –