Second Semester Examination
2021/2022 Academic Session

July/August 2022

EAP215 – Water Supply and Treatment Engineering

Duration : 2 hours

Please ensure that this examination paper consists of **NINE (9)** pages of printed material before you begin the examination.

Instructions: This paper contains **FIVE (5)** questions. Answer **FOUR (4)** questions.

All questions **MUST BE** answered on a new page.

1. (a) Determination of population projection can be done using four methods. Identify a suitable method and calculate the population projection for the large and established City X in the year 2041 based on the given data in **Table 1**.

[10 marks]

Table 1: Population in City X

Year	**Population**
1961	858,545
1971	1,015,672
1981	1,201,553
1991	1,691,538
2001	2,077,820
2011	2,585,862

(b) Explain the physical characteristics of turbidity and total suspended solids related to water quality.

[6 marks]

(c) Describe the importance of the pH evaluation at the abstraction point where the water supply is abstracted and at the final point of a water treatment plant. Distinguish between the two observations.

[5 marks]

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(d) The Environmental Quality (Sewage and Industrial Effluent) Regulations, Environmental Quality Act is the main reference to check water quality from the water supply abstraction. Explain **TWO (2)** comparisons between standard A and B in this matter.

[4 marks]

2. The treatment process of 55,000 m^3/day of water requires 40 mg/L of alum as a coagulant. The natural alkalinity of the river water is equivalent to 6 mg/L of $CaCO^3$.

(a) Determine the dosage of lime as CaO needs to be added to react with alum after the natural alkalinity is exhausted.

[6 marks]

(b) Determine the required quantities of quicklime (containing 80% CaO) and alum in kg/day.

[4 marks]

(c) The design flow for a water treatment plant (WTP) is 5.8×10^3 m^3/d. The rapid mixing tank will have a mechanical mixer and the average alum dosage will be 42 mg/L. The theoretical mean hydraulic retention time of the tank will be 1 minute. The dynamic viscosity is 8.91×10^{-4} Ns/m^2. Determine the following:

i) The quantity of alum needed on a daily basis in kg/day.

ii) The dimensions of the tank in meters for a tank with equal length, width, and depth.

iii) The power input required for a G of 950 s^{-1} and water temperature of 25°C (express the answer in kW)

[15 marks]

3. (a) Two sets of jar tests are conducted on raw water containing 50 NTU and an alkalinity concentration of 38 mg/L expressed as $CaCO_3$. Given the data as shown in **Table 2**, estimate the optimal pH, coagulant dose and the theoretical amount of alkalinity that would be consumed at the optimal dose. The reaction occurs when water is added with alum is shown as:

$$Al_2(SO_4)_3.14H_2O + 6HCO_3^- \rightarrow 2Al(OH)_3 + 6CO_2 + 14H_2O + 3SO_4^{2-}$$

Molecular weights of the elements are shown as:

Oxygen = 16, sulphur = 32, aluminium = 27, hydrogen =1 and carbon = 12.

[15 marks]

Table 2

Jar Test 1						
Jar	1	2	3	4	5	6
pH	5.0	5.5	6.0	6.5	7.0	7.5
Alum dose (mg/L)	25	25	25	25	25	25
Turbidity (NTU)	15	8	6.5	3.2	6	11
Jar Test 2						
Jar	1	2	3	4	5	6
pH	6.5	6.5	6.5	6.5	6.5	6.5
Alum dose (mg/L)	15	20	25	30	35	40
Turbidity (NTU)	13	9	2.5	3.6	6	13

(b) An over and under baffle flocculators consists of three sections, each 6 m long. The baffles are made of wood. The depth of water at the downstream end is 2.6 m and the floor slope is 1 in 100, which is sloping down towards the outlet. When the flow rate is 15 million litres per day (MLD) is passing through it and the water temperature is 25˚C, the overall head loss is measured to be 125 mm and the velocity gradient is 25 s^{-1}.

Calculate the width of the flocculator and the Camp Number. Given the density of water at 25ºC is 978 kg/m^3 and its dynamic viscosity is 8.91 x 10^{-4} Ns/m^2.

[10 marks]

4. (a) A horizontal sedimentation tank has a capacity of 4 million litres per day (MLD), retention time of 3.5 hour and a surface loading of 1.3 m/hour. The tank is designed with length:breadth ratio of 4:1. Calculate the dimensions of the tank and the length of the outlet weir. Sketch the diagram of the outlet weir based on your design. Cd = 1.0

[8 Marks]

(b) Determine the effective size (d_{10}, in mm) and the uniformity coefficient (UC) for the sand filter media characterized by the sieve analysis results presented in the **Table 3**. Plot the % weight passing versus media size in the analysis.

[9 marks]

Table 3

Sieve Number (mm size opening)	% Weight Passing
14 (1.41)	100
16 (1.19)	100
18 (1.00)	94
20 (0.84)	83
25 (0.71)	57
30 (0.59)	30
35 (0.50)	8
40 (0.42)	5
45 (0.35)	1
50 (0.297)	0

(c) Determine the surface area of a settling tank for the city of Pekaka with 0.8 m^3/s design flow using the design overflow rate of 33.5 $m^3/d.m^2$. Compare this surface area with that which results from assuming a typical overflow rate of 20 $m^3/d.m^2$. Determine the depth of the clarifier if the detention time is 100 minutes.

[8 marks]

5. (a) The following **Figure 1** and **Figure 2** show two different scenarios of a water supply system. Elaborate the scenarios with respect to the hydraulic gradient line, energy line and the available consumer head.

[6 marks]

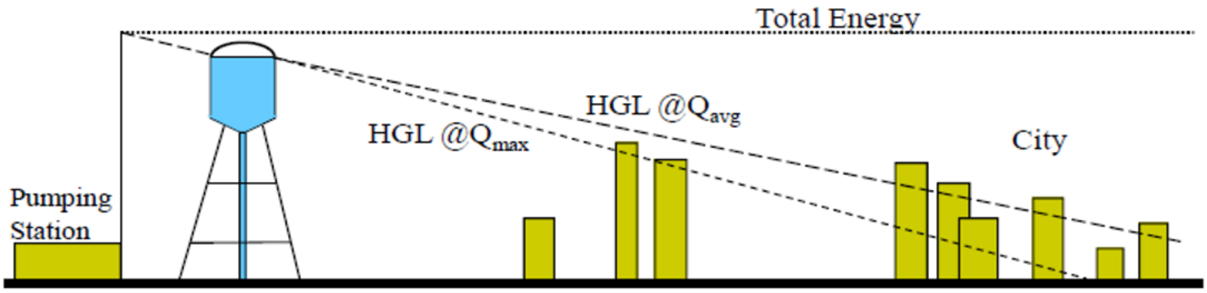

Figure 1: Scenario 1

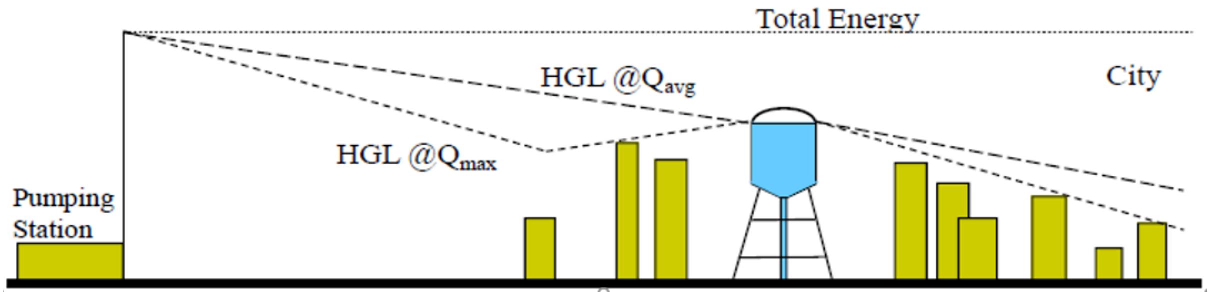

Figure 2: Scenario 2

(b) **Figure 3** shows a water reticulation system. Estimate the flow rate in each pipeline using Hardy-Cross Method and Hazen-William formula for **up to two iterations**. Adopt Hazen-William coefficient, C, as 100. Use initial flowrate of 70 litres per second (L/s) from point A to B. The lengths and diameters for pipes AB, BC, CD, and AD are as follows:

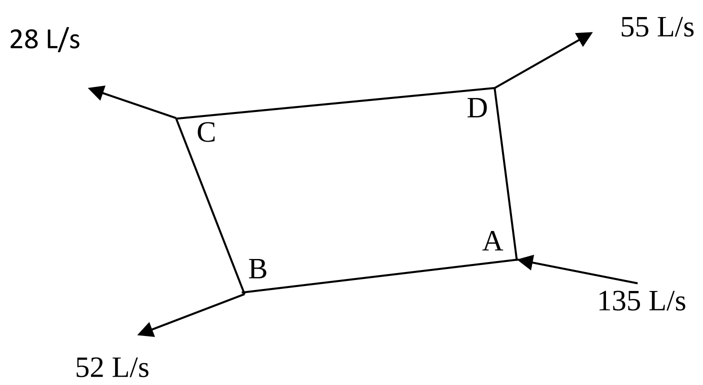

Figure 3: Reticulation system

Pipe AB: length= 900 m and diameter = 250 mm

Pipe BC: length = 650 m and diameter = 200 mm

Pipe CD: length = 1000 m and diameter = 250 mm

Pipe AD: length = 550 m and diameter = 200 mm

This formula might help in your calculation:

$$H_L = \frac{12.25 \times 10^9}{D^{4.87}} L \left[\frac{Q}{C}\right]^{1.85}$$

[19 marks]

APPENDIX

$$P_n = P_i + nI$$

$$P_n = P_i\left(1+\frac{i}{100}\right)^n$$

$$P_n = P_i + n(I+m)$$

$$P_n = P_i\left(1+\frac{(1-k}{100}\right)^n$$

$$G = \left(\frac{P}{\mu\forall}\right)^{1/2}$$

$$P = \frac{1}{2}C_d \rho A \vee^3$$

$$P = \rho Qgh$$

$$h_L = KQ^2$$

$$\frac{d_1}{d_2} = \frac{1}{2}\left[\left(1-8F^2\right)^{1/2} - 1\right]$$

$$F = \frac{V_1}{(gd_1)^{1/2}}$$

$$\mathrm{Re} = \frac{\rho v d}{\mu}$$

$$\Delta H = [(v_1^2 + 5v_2^2 + 4v_3^2)/2g] + \text{normal channel friction}$$

$$h = \frac{nv_1^2 + (n-1)v_2^2}{2g}$$

$$v_s = \frac{gd^2(\rho_s - \rho_w)}{18\mu}$$

$$t = \frac{2\pi H}{Q}\int_{R1}^{R2} r\,dr = \frac{\pi\left(R_2^2 - R_1^2\right)H}{Q}$$

$$V_s = \frac{Q}{A}$$

$$D = V_s t$$

$$L = \frac{0.2Q}{HV_s}$$

$$H = \frac{1128\times10^9}{d^{4.87}}\left[\frac{Q}{100}\right]^{1.85}$$

$$\Delta = -\frac{\Sigma H}{N\sum\frac{H}{Q_a}}$$

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