KATHMANDU UNIVERSITY
End Semester Examination
July/August, 2024

Level : B.Tech.
Year : III
Time : 2 hrs. 30mins.

18 AUG 2024

Course : ENVE 302
Semester : I
F. M. : 55

SECTION "B"
[7 Q. × 5 = 35 marks]

Attempt ANY SEVEN questions. Make logical assumptions wherever required. Some useful information/ formula/equations are provided with this question paper.

1. Census-based population data for a Nepalese town is provided below.

Census Year (A.D.)	1981	1991	2001	2011	2021
Population	15,000	21,000	27,000	34,000	42,000

Calculate the projected water demand for the year 2040 assuming full household plumbing, with industrial consumption representing 20% of domestic demand and water losses accounting for 15% of domestic consumption. Neglect the other demands.

2. The average yield of water from a catchment area recorded every two months is provided below:

Month	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sept-Oct	Nov-Dec
Inflow ($x10^6$ m^3)	3.5	5.6	20.3	19.6	4.77	3.64

In order to fulfill the 4.78 million cubic meters of monthly water demand of the city, determine the required storage capacity of impounded reservoir analytically.

3. Given a water sample with 300 mg/L of total hardness caused solely by Calcium (Ca) and Magnesium (Mg) ions in equal amounts, and a 150 mg/L bicarbonate (HCO_3) concentration. Determine:
   a. The individual concentrations of calcium and magnesium ions.
   b. Water's alkalinity
   c. Carbonate and Non-carbonate hardness

4. Draw plan and section of spring intake showing outlet, overflow and washout pipe. Also, discuss in brief on the protection measures of the spring intake with neat and clean diagram (plan and section).

5. Design a bar screen for a peak average flow of 40MLD. Also calculate the head loss when screen is 50% clogged.

6. Determine the surface area of a sedimentation tank for $0.5m^3/s$ of design flow, using the design overflow rate of $35m^3/m^2/day$. Find the depth of the tank for the overflow rate and detention time of 90 min. Assume necessary data suitably and recommend the tank dimensions.

7. Illustrate and explain the operation (including cleaning) of a rapid sand filter. Compare and contrast the advantages of rapid sand filters over slow sand filters.

P.T.O.

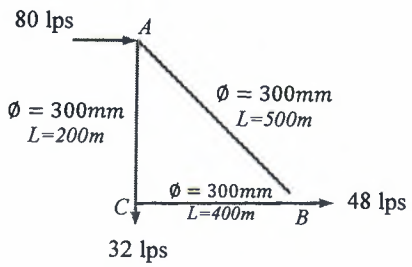
8. Conduct a comparative analysis of alternative water distribution system configurations, evaluating their respective strengths, weaknesses, and operational implications.

SECTION "C"

[2 Q. × 10 = 20 marks]

Attempt ANY TWO questions.

9. The diameter and length of each pipe in a distribution network is shown below. Use Hardy-Cross method with Hazen William's formula to compute the corrected flows in each pipe (Perform at least two iterations). Assume C=100.



10. Design a mechanical rapid mix unit for a design flow to be treated (Q) = 300 m^3/h.
- Detention time (T) = 30s.
- Velocity gradient (G')= 600 s^{-1};
- Rotation speed of impeller (n) = 125 rpm.
- Ratio of tank height to diameter = 1.5:1
- Ratio of impeller diameter to tank diameter = 0.4:1
- Assume μ= 1.0087 * 10^{-3} Ns/m^2; C_d=1.8

Make a neat and clean sketch of your design.

11.

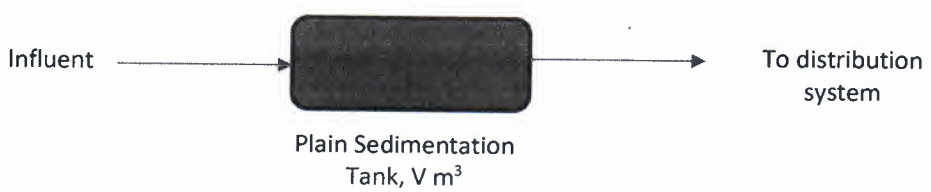
a. What are the things to be considered before supplying water to the community? Draw a schematic diagram if a typical rural water supply systems with the following components: Reservoir, Sedimentation tank, spring source, distribution system, break pressure tank, interruption chamber. [5]

b. Q m^3/s of water is being drawn form a Ground water source to fulfill the drinking water demand of Indrapur town, Morang. A small sedimentation tank, V m^3 (LBH) has been constructed to remove the suspended and settleable solids in the raw water. Discuss on the following: [1+2+2]

i. Additional Q m^3/s from a surface source is added to fulfill the growing demand in the town. What is its impact on the hydraulic retention time the tank?

ii. The surface water added is likely to increase the load of Suspended Solids (SS) in the influent. Discuss on how the size of SS in the influent affects the efficiency of the sedimentation tank?

iii. What do you suggest to increase the efficiency of the sedimentation tank after the addition of the surface source?



List of useful Equations/Formula:

Population Forecasting

- Arithmetic method : $P_n = P_0 + nI$
- Geometric method: $P_n = P_0(1+r_g)^n$
- Incremental Increase method: $P_n = P_0 + nI + \frac{n(n+1)r}{2}$

Water Quality and Treatment

- Carbonate alkalinity $\left(\text{in } \frac{\text{mg}}{\text{L}} \text{ as } CaCO_3\right) = \frac{CO_3^{--} \text{ concentration}}{0.6}$
- Hydroxide alkalinity $\left(\text{in } \frac{\text{mg}}{\text{L}} \text{ as } CaCO_3\right) = \frac{OH^- \text{ concentration}}{0.34}$
- Bicarbonate alkalinity $\left(\text{in } \frac{\text{mg}}{\text{L}} \text{ as } CaCO_3\right) = \frac{HCO_3^- \text{ concentration}}{1.22}$
- Hardness $\left(\text{in } \frac{\text{mg}}{\text{L}} \text{ as } CaCO_3\right) = \text{ion concentration } \left(\text{in } \frac{\text{mg}}{\text{L}}\right) \times \frac{\text{Equivalent weight of } CaCO_3}{\text{Equivalent Weight of ion}}$
- Equivalent weight of $CaCO_3$ is 50.
- Equivalent weights of principal cations Ca^{++}, Mg^{++} and Sr^{++} are 20, 12.2 and 43.8 respectively.
- Stoke's (Laminar) : $V_s = 418\,(S-1)d^2\,\frac{3T+70}{100}$
- Reynold's number, $R_e = \frac{V_s d}{\vartheta}$

S.N.	Law and Equation	Application for range of	
		Reynolds Number	Particle Size in mm, Specific gravity S=2.65 and Temperature T=20°C
1.	Stoke's (Laminar) $V_s = \frac{g d_p^2}{18\,\vartheta}(S-1)$	Up to 1	Up to 0.1
2.	Hazen's (Transition) $V_s = \sqrt{\frac{4}{3}\frac{g\,d_p}{C_D}(S-1)}$ $C_D = \frac{24}{R_e} + \frac{3}{\sqrt{R_e}} + 0.34$	>1 to 2000	>0.1 to 1
3.	Newton's (Turbulent) $V_s = \sqrt{3.33\,g\,d_p\,(S-1)}$	>2000	>1

Temperature °C	0	5	10	15	20	25	30
Kinematic viscosity, ν (Centistokes)	1.792	1.519	1.308	1.141	1.007	0.897	0.804

Design of Rapid Mix/Flocculation Chamber

- Power (P) = $G'^2 \mu V$
- Also, Power (P) = $\frac{1}{2} C_d \rho_w A_b v^3$
- Velocity at tip of impeller (v_b) = $r \cdot \omega$
- Kinematic viscosity (ϑ) = $\frac{Dynamic\ Viscosity\ (\mu)}{Density\ of\ fluid\ (\rho)}$

Water distribution

- Capacity of balancing reservoir = Maximum cumulative surplus + Maximum cumulative deficit + Total demand - Total inflow
-

Formulae	Head loss	K	n
Darcy Weisbach	$\frac{fLQ^2}{12.1\,d^5}$	$\frac{fL}{12.1\,d^5}$	2.0
Hazen William's	$\frac{10.68\,LQ^{1.85}}{d^{4.87}C^{1.85}}$	$\frac{10.68\,L}{d^{4.87}C^{1.85}}$	1.85
Manning's	$\frac{10.294\,n^2LQ^2}{d^{16/3}}$	$\frac{10.294\,n^2L}{d^{16/3}}$	2.0

- $\Delta Q = -\frac{\Sigma h_f}{n\,\Sigma\frac{h_f}{Q}}$

Design of Screens

- $h_L = \frac{1}{C}\left(\frac{V^2 - v^2}{2g}\right)$; use C = 0.7 for a clean screen and 0.6 for a clogged screen

TABLE 11.2 DESIGN INFORMATION FOR BAR RACKS.

Item		*Hend Cleaned*	*Mechanically cleaned*
1. Bar size :			
Width	(mm)	5-15	5-15
Depth	(mm)	27-75	25-75
2. Clean spacing between bars	(mm)	25-50	15-75
3. Slope from vertical	(deg.)	30-45	0-30
4. Approach velocity	(m/s)	0.3-0.6	0.6-1.0
5. Allowable head loss	(mm)	150	150

TABLE 11.3. USUAL BAR SIZES AND OPENINGS.

Dimension of bar facing the flow (mm)	*Clear spacing between bars (mm)*	$\frac{\text{Area of the opening}}{\text{Gross surface area of screen}} \times 100$
6	18	75
6	24	80
6	30	83.3
6	36	85.6
9	18	66.7
9	24	72.8
9	30	77
9	36	80
12	18	60
12	24	66.7
12	30	71.5
12	36	75

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SECTION "A"
[20 Q. × 1 = 20 marks]

Make reasonable assumptions for any missing data or information. Mark [X] the best answer.

1. Which of the following is *NOT* the related to collection chamber?
   [ ] Water from one or more sources
   [ ] Breaks the incoming water pressure into atmospheric pressure
   [ ] Prevent the back flow of water
   [ ] Located near to the treatment site

2. Three streams having discharge of $4m^3/s$, $1m^3/s$ and $5.5m^3/s$ having pH value of 6.0, 7.0 and 8.0 meet at a single point. The pH measured downstream of meeting point (assume complete mixing occurs) is:
   [ ] 6.4 [ ] 5.5 [ ] 7.0 [ ] 4.3

3. Design year is :
   [ ] Base year + Base period [ ] Design period – Base year
   [ ] Survey year + Base year [ ] Base year + Design period

4. Settling of biomass in a Secondary clarifier of wastewater treatment plant is the example of :
   [ ] Discrete [ ] Flocculent [ ] Zone [ ] Compression

5. Which of the following is *NOT* the characteristics of colloidal particles?
   [ ] charged particles
   [ ] cannot settle down by plain sedimentation
   [ ] surface phenomena predominant over mass phenomena
   [ ] $10^3\mu$ to 1μ

6. When activated silica is typically added in the water treatment process?
   [ ] before alum [ ] at the same point as alum
   [ ] never added [ ] only after filtration

7. Which of the following is NOT true for an ideal sedimentation tank having Length (L) and Breadth (B) and Height (H) is receiving a discharge of Q m^3/s.
   [ ] Sediments are uniformly distributed
   [ ] equal velocity at all points lying in the each vertical
   [ ] All particles having settling velocity < Q/BL will escape from the tank
   [ ] the settling path is the resultant of horizontal velocity and settling velocity

8. Plain sedimentation is expected to remove particles of specific gravity ____.
   [ ] <1 [ ] >1.2 [ ] = 2.65 [ ] < 2

9. Which of the following statements accurately describes the role of a Break Pressure Chamber (BPC) in distribution mains?
   [ ] Increases the pressure rating of pipes to accommodate high-pressure systems, reducing overall costs.
   [ ] Enables the use of low-pressure rating pipes in distribution mains, leading to cost optimization.
   [ ] Minimizes the need for pipes in distribution mains, thereby reducing construction expenses.
   [ ] Regulates water flow in distribution mains, resulting in improved system efficiency.

(For Q.10 & Q.11) A source of average discharge 2 lps was identified for a village water supply scheme. Sedimentation tank of 14.5 m^3 for purification before distribution is designed.

10. What is the Hydraulic retention time(HRT) of the sedimentation tank:
    [ ] 2 h [ ] 11.92 h [ ] 0.08 h [ ] 0.5 h

11. If the Surface overflow rate of the sedimentation tank is 172.8 $m^3/m^2/day$, tank depth = ___ m.
    [ ] 10 [ ] 0.7 [ ] 17.28 [ ] 14.5

12. In a flash mixer, using coagulant in _____ form will decrease the Hydraulic Retention Time (HRT) during water treatment?
    [ ] solid [ ] liquid [ ] granular [ ] powdered

13. During a routine check, a water treatment plant measures a hydraulic head loss (h_L) of 30 cm in a bar screen. If the approach velocity (v) is 0.65 m/s and the velocity of flow through the openings (V) is observed to be 2.0 m/s, what is the value of empirical discharge coefficient (C)?
    [ ] 0.61 m [ ] 0.607 [ ] 0.006 [ ] 60 m

14. In the context of water treatment and bridging mechanisms, how does the molecular weight of bridging agents impact their effectiveness?
    [ ] Higher molecular weight forms more stable and effective bridges
    [ ] Higher molecular weight decreases the stability of bridges, reducing effectiveness
    [ ] Lower molecular weight promotes the formation of stronger bridges, enhancing effectiveness
    [ ] Molecular weight plays a negligible role in the effectiveness of bridging agents

15. The major disadvantages of intermittent system of supply of water is:
    [ ] bigger pipes and pumps required
    [ ] more number of valves required
    [ ] infiltration of impurities may occur through leaky joints
    [ ] consumers should store water

16. A water treatment plant is designed to treat 1m^3/s of raw water. It has 14 sand filters. Surface area of each filter is 50m^2. What is the loading rate (in $m^3/m^2/day$) with two filters out of service for routine backwashing?
    [ ] 123.43 [ ] 144 [ ] 1728 [ ] 0.02

17. What is 'equivalent length' of pipe used for?
[ ] determining flow in open channels
[ ] calculating head losses in a compound pipe system
[ ] modelling minor losses due to fitting and other appurtenances
[ ] sizing thrust blocks

18. For parallel pipes with the same elevation, material, age and diameter, _____ are equal.
[ ] velocities [ ] head losses [ ] flow [ ] internal pressure

19. Water flows through a pipe with a diameter of 20 cm at a velocity of 3 m/s. It then enters a sudden enlargement to a diameter of 30 cm. The head loss due to this sudden enlargement is approximately:
[ ] 0.15m [ ] 0.3m [ ] 0.45m [ ] 0.6m

20. Check valve is to:
[ ] regulate the flow [ ] control the flow in the pipeline
[ ] allow the flow only in one direction [ ] release the excessive air pressure