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

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| Study Programme | : Bachelor of Technology Honours in Engineering |
| Name of the Examination | : Final Examination |
| **Course Code and Title** | **: CVX7242 - Environmental Engineering Design** |
| Academic Year | : 2021/2022 |
| Date | : 20th February 2023 |
| Time | : 0930-1230hrs |
| Duration | **: 3 hours** |

## General Instructions

1. Read all instructions carefully before answering the questions.

2. This question paper consists of **Seven (7)** questions in **Six (6)** 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 / equations are provided in last page

6. This is a Closed Book Test **(CBT)**.

7. Answers should be in clear handwriting.

8. Do not use red colour pen.

## Question 1

(a) *Sizing of units* based on unit operations means the determination of capacity (volume) and the dimensions of the treatment tanks.
   (i)   A treatment system consists of circular settling unit. For the design average rate of 6ML/d and for the minimum detention time of 4 hours, what would be the capacity of the tank.
   (ii)  If the maximum overflow rate is $20m^3/m^2/d$, determine the required diameter of the tank and the side water depth, SWD.

   *[07 marks]*

(b)
   (i)   What are the three major components of a distribution system which needs to consider during the designing.
   (ii)  List three requirements of good distribution system
   (iii) Discuss the problems that can be occurred in the distribution systems.
   (iv)  What is meant by 'NRW' or Non-Revenue Water. Describe briefly how the losses are occurred.

   *[08 marks]*

(c) A small town has 32,000 of population and an average per capita water demand is 500L/d. Assuming that the need for equalizing storage is 20% Of the average daily demand and that storage for a fire flow of 60L/s for a 4h duration is required, compute the required volume of a distribution storage tank for the town.

   *[05 marks]*

## Question 2.

(a) In a steady-state conservative system, pollutants enter and leave the region at the same rate.
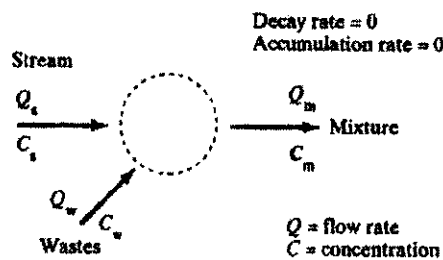


   (i)   Assuming steady-state conditions, write mass balance equation for the above system.
   (ii)  An urban stream flowing at $20.0 m^3/s$ has a tributary feeding into it with a flow $2.0 m^3/s$. The tributary Nitrate concentration of 24mg/L, while the same pollutant concentration at the upstream of the junction is 1.5 mg/L. Assuming nitrate as a conservative substance, and assuming complete mixing of the two streams, find the downstream nitrate concentration.

   *[07 marks]*

(b)
(i) In a narrow and deep settling tank more effective in removing suspended solids than a wide and shallow tank? Explain your answer.

(ii) Compute the required volume of a sedimentation tank that provides 3h of detention time for a flow of 10ML/d. If the tank is 10m by 25m in plan dimensions, how deep is the water in the tank?

*[06 marks]*

(c)
(i) Explain what is meant by 'short-circuiting' in a sedimentation tank. Briefly explain the reasons for the occurrence of short-circuiting.

(ii) Compute the minimum design velocity, in meters per seconds (m/s) of suspended particles that can be completely removed in a sedimentation tank. The overflow rate 40 $m^3/m^2/d$.

*[07 marks]*

## Question 3.

(a) Wastewater generation and its characteristics are fluctuating from a town to town and from a community to a community.
   (i) List the factors that effect on wastewater characteristics.
   (ii) A combined wastewater flow from a community consists of 200gpcd from 7500 persons, 65000 gpd from a milk processing plant with BOD 1400 mg/L, and 40,000 lpd containing 225Kg of BOD from dry fruit manufacturing factory. Calculate the combined wastewater flow, BOD concentration in the composite waste and BOD equivalent population.

*[06 marks]*

(b) A wastewater treatment plant has two primary clarifiers, each 20 m in diameter with a 2-m side-water depth. The effluent weirs are in both channels set on a diameter of 18m. For a flow of 12900 $m^3/d$, calculate the overflow rate, detention time and weir loading.

*[05 marks]*

(c) Skimming tanks are provided to remove oil, grease, and other small floating materials such as vegetable debris, etc. A kitchen of a 100 rooms hotel produces 500 $m^3$/day of domestic wastewater seek your assistance to improve their wastewater treatment plant.

The hotel management wants to maintain the efficiency of oil and grease removal at 80%. If the oil and grease concentration is 200 mg/l and the proposed detention time is 20 minutes, design the capacity of the skimming tank.
   (i) Compute the Oil and grease concentration of the effluent.
   (ii) If surface load is 250 m2/m3/s, what would be the surface area of the tank?
   (iii) Assuming the length to width ratio is 3:1, calculate the skimming tank's length and width.
   (iv) Providing a freeboard of 0.5 m, determine the depth of the tank and the design summary (dimensions) of the tank.

*[09 marks]*

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**Question 4.**

(a)
  (i)    Differentiate 'dry well' and 'wet well'.
  (ii)   What are the significant factors that are considered in the design of a pump house?
  (iii)  For a small town it is needed to design a rising main.

   The design details are as follows.
           Peaking factor - 2.5
           Daily average flow :15 MLD.
           Minimum flow is 40% of the average flow.
           Flow through velocity in the rising main:75 m/s

   Assume if design data are needed.

                                                                    *[06 marks]*

(b) The aeration tank for a completely mixed aeration process is being sized for a design wastewater
    flow of 7500m³/d. The influent BOD is 130mg/L with a soluble BOD of 90mg/L. The design effluent
    BOD is 20mg/L with a soluble BOD of 7.0 mg/L. Recommended design parameters are sludge age
    of 10 days and volatile MLSS of 1400 mg/L. Selection of these values taken into account the
    anticipated variation in wastewater flows and strengths. The kinetic constants from a bench scale
    treatability study are Y= 0.60 mg VSS mg soluble BOD and $k_d$=0.06 per day. Calculate the volume
    of the aeration tank, aeration period, food/Microorganism ratio and the excess biomass in the
    waste activated sludge.
    If required use the following equations with usual notations.

$$\frac{1}{\theta_c^{min}} = \frac{YKS_0}{(K_s + S_0)} - K_d$$

                                                                    *[08 marks]*

(c) Attached growth biological system employed for wastewater treatment essentially consists of a
    reactor with some kind of medium to support the growth of biomass on it.
    (i)    List four types of Attached growth systems
    (ii)   Explain the removal mechanism briefly.

                                                                    *[06 marks]*

**Question 5.**

(a) A conventional activated sludge system treats 11,000 m³/d of wastewater with a BOD of 180 mg/L
    in an aeration tank with a volume of 3400m³. The Operating conditions are an effluent suspended
    solid of 20mg/L, an MLSS concentration maintained in the aeration tank of 2500 mg/L, and an
    activated – sludge wasting rate of 160m³/d containing 8000 mg/L. Using the above data, calculate
    the aeration period, volumetric BOD loading, F/M ratio and sludge age.

                                                                    *[10 marks]*

(b) State the two main reasons why an activated sludge system is operated at a relatively low food/microorganism ratio. What happened if the F/M ratio is high (>1) in the system?

*[03 marks]*

(c)
(i) Define Sludge Volume Index (SVI) and explain its use in the design and operation of an activated sludge plant.
(ii) An aeration system with a hydraulic retention time of 4hour receives a flow of 3ML/d at a BOD of 440 mg/l. The MLSS concentration in the aeration tank is 3,500 mg/l. The effluent BOD is 20 mg/l. Calculate, the volume of the aeration tank.
(iii) What is the SVI of the system.

*[07 marks]*

## Question 6.

(a)
(i) Describe the role of algae in biological stabilization of wastewater in a stabilization pond.
(ii) Calculate the surface area required for a stabilization pond to serve a domestic population of 1000. Assume 180 lpcd at 210 mg/l of BOD. Use a design loading of 0.1kg of $BOD/m^2/day$. If the average liquid depth is 0.6 m, calculate the retention time of the wastewater based on influent flow. The effluent is spread on grassland by spray irrigation at a rate of 10cm/week. Compute the land area required for land disposal. In these computations assume no evaporation or seepage losses from the ponds.

*[08 marks]*

(b)
(i) How Landfills and open dumps are contributing for global warming? Explain briefly.
(ii) What elements to be included in the landfill design and construction that permit control of leachate and gas?

*[05 marks]*

(c)
(i) What is meant by 'Integrated Solid Waste Management'? How it helps to manage solid waste specially in a small city?
(ii) What is known as a Life Cycle Analysis (LCA). How it helps pollution prevention. Explain briefly.
(iii) What do you understand by Circular Economy'. What aspects of circular economy can apply for solid waste management and net zero carbon in future. Discuss.

*[07 marks]*

**Question 7.**

(a)

(i) A stack at a power station has an emission exiting at 3.5 m/s through a stack diameter of 3 m. The average wind speed is 15 m/s. The temperature at the top of the stack is 300°C, and the temperature of the emission is 1850 °C. The atmosphere is at neutral stability. What is the expected rise of the plume?

For stable condition, $S = g/T_o(\Delta T_o/\Delta Z + 0.01)$ C/m ; $\Delta H = 2.4 \{F/US\}^{1/3}$

(ii) A stack gas contains Carbon Monoxide (CO) at a concentration of 10% by volume. What is the concentration of CO in $\mu g/m3$? (Assume 25 °C and 1 atmospheric pressure)

*[08 marks]*


(b)

(i) The level of noise can be reduced by using one of three strategies. Explain briefly.

(ii) Briefly explain the measures that you are taken to reduce the traffic noise,

A. At a roadside

B. At a highway (Express way)

*[06 marks]*


(c) An air pollution control device is to remove a particulate that is being emitted at a concentration of 125,000 $\mu g/m^3$ at an air flow rate of 180 $m^3/s$. The device removes 0.48nmetric ton per day. What are the emission concentration and the collection recovery?

*[06 marks]*


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