B.Sc. Engg. (CEE)/6th Sem. 29th May, 2024 (Morning)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

TERM: FINAL SEMESTER EXAMINATION
COURSE NO.: CEE 4633
COURSE TITLE: Waste Water Engineering and Environmental Sanitation

SUMMER SEMESTER: 2022-2023
TIME: 3 Hours
FULL MARKS: 150

There are **6 (Six)** questions. Answer **ALL** questions. Programmable calculators are not allowed. Do not write on this question paper. The figures in the right margin indicate full marks and corresponding CO and PO in the brackets. Symbols convey their usual meanings. Assume reasonable values for any design data.

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1. (a) Explain briefly the hierarchy of USEPA-preferred solid waste management strategies and the paradigm shift for the 21st century with a diagram. **(5)** (CO1, PO1)

(b) Explain the operational sequence of hauled container system for exchange container mode with a diagram. **(5)** (CO1, PO1)

(c) Determine the statistical characteristics of the waste collection data (mean, median, mode, standard deviation, coefficients of variation, skewness and kurtosis). Table 1 is provided in Appendix to obtain the statistical characteristics of waste. **(18)** (CO2, PO2)
Verify the distribution by the statistical characteristics whether it is normal or skewed using i) α_3 and α_4, and ii) mean, median and mode.
Sketch a diagram in a plain paper to explain the distribution of normal or skewed (positively/negatively).

2. (a) Explain briefly the interrelationships between the functional elements in solid waste management system with a diagram. **(5)** (CO1, PO1)

(b) Sketch the various components of a SBS system and describe briefly. **(5)** (CO1, PO1)

(c) Design a sanitary landfill in Sylhet to handle 30 years (design life) of MSW generation for a town of 10,00,000 people. Assume per capita national average discards 3 lb/d, no combustion, a landfill density of 1000 lb/yd^3 and the average depth of the compacted solid waste is 10 ft. Assume 20% of the cell volume is native soil used for cover. **(12)** (CO3, PO3)
Estimate the landfill area (in acre) needed to manage properly the MSW.
Design and sketch a sanitary landfill with proper dimensions.
Why is native soil used as daily cover?

3. (a) Do you think treated industrial effluent with pH of 5, TS of 2100 mg/L, As of 0.2 mg/L, BOD of 100 mg/L and COD of 400 mg/L is allowed to discharge into inland water in Bangladesh according to ECR and why? **(5)** (CO1, PO1)

(b) Sketch a process flow diagram to treat a municipal wastewater that has a high concentration of suspended solids, organic matter and pathogens. Also, illustrate a sludge treatment option. Describe briefly the wastewater and sludge treatment processes. **(5)** (CO1, PO1)

(c) Estimate the unit solid waste generation rate (in kg/cap.d) for a residential area consisting of 1200 homes in Dhaka. Number of compactor truck loads is 9 and the average size of compactor truck is 20 yd^3 where specific weight of waste is 500 lb/yd^3. Number of flatbed loads is 7 and the average size of flatbed is 2 yd^3 where specific weight of waste is 225 lb/yd^3. Number of private vehicle loads is 20 and the average size of private vehicle is 8 ft^3 where specific weight of waste is 150 lb/yd^3. Assume that each household is comprised of 5 people. **(12)** (CO2, PO2)

What will be the impact on waste generation stream if a few residents start to segregate some items (e.g. tin can, paper and metal) for recycling in their houses?

4. **(a)** Sketch a diagram of a typical circular gravity thickener and describe briefly. **(5)** (CO1, PO1)

(b) Sketch a diagram to show groundwater pollution from pit latrines and explain it. **(5)** (CO1, PO1)

(c) People living in a coastal area in Khulna use the harvested rainwater for various purposes. The average yearly rainfall intensity in Khulna is 2.4 m and the runoff coefficient is 0.7. Note that the area has no supply water. **(12)** (CO3, PO3)

Calculate the minimum catchment area required for a family of 10 persons to be supplied with 20 lpcd of water throughout the year.

Design a rectangular rainwater storage tank where 60% of the rainwater must be stored for uninterrupted water supply throughout the year.

Estimate the amount of domestic wastewater production (m^3/yr) in the house.

How can you treat the harvested rainwater? Explain the potential uses of treated rainwater.

5. **(a)** Define septic tank. Where can we use septic tank? Sketch the various components of a septic tank. **(4)** (CO1, PO1)

(b) Design a septic tank to serve a family of 10 people who produces 90 lpcd of wastewater. The tank is to be desludged every 3 years. Assume that the design temperature is 25°C, sludge accumulation rate is 0.06 m^3/cap.yr, tank cross-sectional area is 3 m^2 and the minimum scum clear depth is 75 mm. **(16)** (CO3, PO3)

Determine HRT and volume required for the sedimentation, sludge digestion and sludge storage.

Design and sketch a two-compartment septic tank with proper dimensions.

Can you discharge the effluent of septic tank to the Turag River? Explain briefly.

How can you deal with the sludge if the tank full and with effluent of septic tank?

(c) Design and sketch a soakage pit for the disposal of effluent from the septic tank (mentioned above), if the soil is sandy loam with a long-term infiltration rate of about 30 $L/m^2.d$. **(6)** (CO3, PO3)

What will be your suggestion if the groundwater table is high (assume 5 m from GL)?

What are the alternative options for the disposal of effluent from the septic tank?

6. **(a)** Describe any two conventional types of sewerage systems with diagrams. **(6)** (CO1, PO1)

(b) A sanitary sewer system for a modern town of 40 km^2 is to be designed as a separate sewer system, which is intended to receive domestic, commercial & industrial wastewater, and groundwater infiltration. The population of the town **(24)** (CO3, PO3)

was 180,000 in 2010 and 220,000 in 2020. What will be the population in 2050 in the town.

The domestic water consumption rate in the town is assumed as 400 lpcd from the supply water. Determine the quantity of domestic wastewater flow (m^3/d) for the use of supply water in the town using the population in 2050.

The RWH system is installed in each tower for WC flushing. Assume that 84 flats/tower, 7 persons/flat, 3 L RW/flush, 10 flush/WC.d and 4 WCs/flat. Design a small reserve tank (externally mounted) in a flat for the harvested RW and a rooftop RW tank for a tower. Determine the quantity of domestic wastewater flow (m^3/d) for the RWH system in the town using the population in 2050.

The commercial & industrial wastewater flow, and groundwater infiltration rates are assumed as 100 lpcd, 200 lpcd and 5,000 L/hectare.day, respectively in the town. Estimate the total wastewater flow (m^3/d) in the town by considering domestic (supply water and RW), commercial & industrial wastewater, and groundwater infiltration using the population in 2050.

Formulae:

$$t_h = 1.5 - 0.3 \log (Pq) \qquad V_h = 10^{-3} P q t_h \qquad V_d = 0.5 \times 10^{-3} \times Pt_d$$

$$d_{sc} = 0.82 - 0.26 A \qquad k_T = k_{20} (\theta)^{T-20}$$

$$\bar{x} = \frac{\Sigma x}{n} \qquad s = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n}} \qquad CV = \frac{100 s}{\bar{x}} \qquad \alpha_3 = \frac{2(\bar{x} - Mod}{s}$$

$$\alpha_4 = \frac{\Sigma (x_i - \bar{x})^4 / n}{s^4}$$

Appendix:

Table 1 Solid waste generation per week

Week no.	Waste, m^3/wk
1	29
2	30
3	35
4	34
5	38
6	41
7	40
8	37
9	38
10	35
11	33
12	32
13	31