(17)

B.Sc. Engg. (CEE)/ 8th Sem.

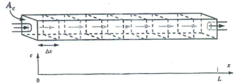
14 May 2024
10:00 A.M to 01:00 P.M

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

Semester Final Examination — **Summer Semester: 2022 - 2023**
Course No.: CEE 4835 — **Full Marks: 150**
Course Title: Environmental Modelling — **Time: 3 Hours**

There are **6 (Six)** questions. **Answer all the 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. Symbols convey their usual meanings. Assume reasonable data/values for any missing data/info.

1. (a) Why is longitudinal dispersion stronger than transverse dispersion? Justify it with a diagram. (CO1:PO1:3)
   (b) What is the difference between a mechanistic and empirical model? What are the benefits of environmental modelling? (CO1:PO1:5)
   (c) Which parameter is used to explain a lake's assimilative capacity? Briefly explain its significance in a lake. (CO1:PO1:5)
   (d) Use the cascade model to simulate the steady-state distribution of concentration in an elongated tank, as shown below: (CO2:PO2:12)

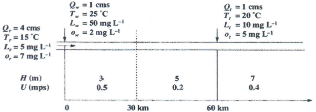


   The tank has cross-sectional area $A_c = 20$ m^2, total length L = 200 m, velocity V = 200 m/hr, first order reaction rate k = 2 hr^{-1}. The inflow concentration is 2 mg/L. Use n = 1, 2, 3 and 4. Plot the results.

2. (a) What is a particular solution? Explain the different loading functions W(t) with respect to time for a CSTR. (CO1:PO1:5)
   (b) A flow of 2 cms with a 5-d BOD of 10 mg L^{-1} is discharged from an activated-sludge treatment plant to a stream with a flow of 5 cms and zero BOD. Stream characteristics are $k_{r,20} = 0.2$ d^{-1}, cross-sectional area = 25 m^2, and T = 28°C. (CO2:PO2:7)
   (i) What is the concentration of BOD at the mixing point?
   (ii) How far below the effluent will the stream BOD concentration fall to 5% of its original value?
   (c) Explain with diagram the changes in the biota downstream from a sewage treatment plant effluent. (CO1:PO1:6)
   (d) A waste source ($Q_w = 10$ cms, $L_w = 200$ mg L^{-1}, $o_w = 2$ mg L^{-1}, $T_w = 25$°C) discharges into a stream ($Q_r = 10$ cms, $L_r = 2$ mg L^{-1}, $o_r = 10$ mg L^{-1}, and $T_r = 15$°C). Downstream, the velocity is 0.3 mps and the depth is 0.3 m. Calculate the profiles of both BOD and oxygen downstream, assuming that the stream is located at 5500 ft elevation and that the BOD decays at a rate of 1 d^{-1}. Determine the value and the location of the maximum deficit. (CO2:PO2:7)

3. (a) How are closed and open systems (show in a diagram) influenced by BOD decomposition? (CO1:PO1:

(b) Determine the profiles of BOD and dissolved oxygen for the following sea-level stream: (CO2:PO2:9)



(c) Explain significance of the following contaminants- (CO1:PO1:6)

i. Fluoride
ii. Arsenic
iii. Carbon

(d) What are the different sources of groundwater pollution? Draw a schematic diagram showing the fate and transport of groundwater contaminants. (CO1:PO1:6)

4. (a) Explain the use and limitations of Bioscreen software. (CO3:PO5:7)

(b) What are the drivers, processes, variables and fluxes of ecosystem models? How can groundwater contamination be controlled (show it with a diagram)? (CO1:PO1:5)

(c) Explain the Lotka-Voltera equations for the ecosystem model. Write down the assumptions for the Lotka-Voltera equations. (CO2:PO2:8)

(d) Explain with diagram of state-space (vector field) representation of numbers of predators and prey for the Lotka-Volterra model. Use the given table and explain the model by plotting the data in a normal graph paper. (CO2:PO2:5)

Year	Prey Population (Spotted Deer)	Predator Population (Bengal Tiger)
2010	15,000	120
2011	15,500	125
2012	16,000	130
2013	16,500	135
2014	17,000	140
2015	17,500	145
2016	18,000	150
2017	18,500	155
2018	19,000	160
2019	19,500	165

5. (a) Explain the effect of transport processes on contaminant concentration in groundwater (Show it with a diagram). (CO1:PO1:5)

(b) Write down the difference between dispersion and diffusion with respect to contaminants movement in ground water. (CO1:PO1:5)

(c) A column experiment is set up in the laboratory. Sand with a mean grain size of approximate 0.5 mm is packed (porosity 0.3) into a cylindrical column, 2 m in length and 20 cm in dia. 10 mg of Sulfur dye is injected into the column (pulse injection). Given, Hydraulic gradient is 0.3 and hydraulic conductivity 1m/hr. (CO2:PO2:15)

i. What will be the concentration of Sulfur dye after an hour at a distance 1.1 m down the column?

ii. When the tracer mass is centered (peak) 1.5 m down the column, what is the concentration of tracer at this location?

If the inflow of pure water is replaced by inflow of a solution with Sulfur dye concentration of 10 mg/L beginning at t = 0 (continuous injection), what will be the concentration of Sulfur dye at a distance 1.1 m down the column after an hour?

6. (a) What is RCM and CCSM? Describe the limitations of RCM and GCM. (CO1:PO1:4)

(b) Explain the different types of environmental models. Discuss the sources and types of air quality models. (CO1:PO1:4)

(c) A large power plant has a 250-m stack with inside radius 2 m. The exit velocity of the stack gases is estimated at 15 m/s, at a temperature of 140°C (413 K). Ambient temperature is 25°C (298 K), and winds at stack height are estimated to be 5 m/s. Estimate the effective height of the stack if the atmosphere is stable with temperature increasing at the rate of 2°C/km. Using the given equations $F = gr^2 v_s(1 - \frac{Ta}{Ts})$, $\Delta h = 2.6(\frac{F}{u_h S})^{\frac{1}{3}}$, $S = \frac{g}{T_a}(\frac{\Delta T_a}{\Delta z} + 0.01°C/m)$ (CO2:PO2:7)

(d) A point source with effective stack height of 50 m emits 80 g/s of NO_x on a clear summer day with surface winds at 4 m/s. Winds at 50 m are 5 m/s. An inversion layer starts at an
elevation of 250 m. Draw a schematic diagram for solving the problem. (CO2:PO2:10)
(i) Estimate the ground-level NO_x concentration at a distance of 4 km downwind from the stack.
(ii) If there had been no inversion layer, estimate the concentration 4 km downwind.

Appendix

Atmospheric Stability Classifications

Surface Windspeed[a] (m/s)	Day Solar Insolation: Strong[b]	Day Solar Insolation: Moderate[c]	Day Solar Insolation: Slight[d]	Night Cloudiness[e]: Cloudy (≥4/8)	Night Cloudiness[e]: Clear (≤3/8)
<2	A	A–B[f]	B	E	F
2–3	A–B	B	C	E	F
3–5	B	B–C	C	D	E
5–6	C	C–D	D	D	D
>6	C	D	D	D	D

- Equation for Air Quality Modelling $\sigma_y = a\,x^{0.894}$ and $\sigma_z = cx^d + f$

Values of the Constants *a, c, d,* and *f* for Use in (47) and (48)

Stability	a	$x \le 1$ km: c	$x \le 1$ km: d	$x \le 1$ km: f	$x \ge 1$ km: c	$x \ge 1$ km: d	$x \ge 1$ km: f
A	213	440.8	1.941	9.27	459.7	2.094	−9.6
B	156	106.6	1.149	3.3	108.2	1.098	2.0
C	104	61.0	0.911	0	61.0	0.911	0
D	68	33.2	0.725	−1.7	44.5	0.516	−13.0
E	50.5	22.8	0.678	−1.3	55.4	0.305	−34.0
F	34	14.35	0.740	−0.35	62.6	0.180	−48.6