



M.E DEGREE EXAMINATIONS: APRIL / MAY 2023

(Regulation 2018)

Second Semester

ENVIRONMENTAL ENGINEERING

P18EET2002: Water Quality Modelling

COURSE OUTCOMES

- CO1:** Develop conceptual schematics required for modeling.
- CO2:** Assess the surface water quality modeling performance.
- CO3:** Design the transport phenomena for different reactor models.
- CO4:** Predict groundwater flow and contaminant transport.
- CO5:** Develop Numerical models to simulate the water quality.

Time: Three Hours

Maximum Marks: 100

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Assertion (A): Mathematical modeling helps the researcher to reduce the cost invested on a technological innovation CO1 [K₁]
Reason (R): Influence of Parameter variations may be well studied through a mathematical model and it can be a replacement of lab studies
a) Both A & R are individually correct, and R is the exact reason for A b) Both A & R are individually correct, and R is the not exact reason for A
c) A is correct and R is invalid d) A is invalid and R is correct
2. To model the irregular surface water spread area, the most suitable discretization will be CO5 [K₁]
a) Finite point mechanism b) Finite Element Method
c) Finite Difference method d) Control volume approach
3. In a modeling approach, if a model tries to mimic the existing field reality, then it is termed to be CO1 [K₁]
a Prediction model b Simulation model
c Computational model d Optimization model

4. Matching type item with multiple choice code

CO4 [K₁]

List I	List II
A. Unsaturated aquifer	i. Darcy equation
B. Saturated aquifer	ii. gradient in water level
C. Flow velocity	iii. Richards equation
D. thickness of the flow media	iv. Transmissivity

A B C D

- a) i ii iii iv
 b) iii i iv ii
 c) iii i ii iv
 d) i iii iv ii

5. The Streeter Phelps equation is used to simulate the Do levels in a river that is flowing at a velocity of 2.5 m/s. If the temperature increases by 1 degree Celsius CO2 [K₂]

Assertion (A): The maximum Do holding capacity of the river increases

Reason (R): Oxygen saturation is influenced by the surface air temperature

- a) Both A & R are individually correct, and R is the exact reason for A b) Both A & R are individually correct, and R is the not exact reason for A
 c) A is correct and R is invalid d) A is invalid and R is correct

6. In a river-lake system, the river feeds the lake with a water quality that has high BoD because of the effluent that is being discharged by the industries that are located along the river course. The local government authority has approached you to develop a lake water quality model. In the above case, how you showcase the dependability of your developed model prediction based on CO2 [K₂]

- a) Calibration b) Parameter estimation
 c) Performance Index d) Number of parameters

7. In case of PFR, in the process of developing the design or performance equation, a small strip within the reactor this is due to CO3 [K₂]

- a) The change in concentration along the length of the reactor, and mass balance cannot be applied if concentration is changing within the domain of study or control volume b) The change in concentration along the width of the reactor is constant, that is reason mass balance is applied to small strip
 c) PFR length may infinite, that is the reason mass balance is applied to a small strip and integrated to the length of the reactor d) That is a base assumption made in PFR design

8. An electroplating industry is discharging its effluent in the nearby water body. From the water sample analysis, it is understood that the effluent has quantifiable heavy metals that are toxic to the human food chain. In the above case, whether the governing equation will consider CO2 [K₂]
- a) Advection Phenomenon b) Advection & Diffusion
 c) Diffusion / Dispersion d) Advection and Diffusion as pseudo coupled phenomenon
9. Assume a case, where the river flows at a stage height of 0.25 m with a flow velocity of 0.6 m/s. In such a case, whether interaction between atmospheric air and river flow has to be modelled. If so the influence of this interaction will be reflected in CO2 [K₂]
- a) Oxygen saturation b) Microbial growth
 c) Critical length of dilution d) Mixing length
10. In a river-lake system, the river feeds the lake with a water quality that has high BoD because of the effluent that is being discharged by the industries that are located along the river course. The local government authority has approached you to develop a lake water quality model. In the above case, sequence the steps listed below, to build up a modeling approach CO2 [K₂]
1. Do water sampling in the lake
 2. Set up the governing equation
 3. Understand the field reality of the river-lake system (boundary conditions)
- Creating appropriate assumptions
- a) 1-3-2-4 b) 1-4-2-3
 c) 1-3-4-2 d) 1-2-3-4

PART B (10 x 2 = 20 Marks)

11. A research team has strong hold on conducting experimental studies and you are supposed to pitch the importance of mathematical modelling. What all be your claims that supports or emphasize the need of mathematical modelling? CO1 [K₂]
12. Whether calibration is required for developed mathematical relation, if so justify your view point. CO1 [K₂]
13. For river noyyal, you are supposed to develop a water quality model capturing Dissolved oxygen. What will be your independent variables and dependent variables? CO2 [K₂]
14. You are supposed to model a river flow (the flow depth is almost 0.1 m), which has a width of 0.5 km. Whether you will consider atmosphere interaction in your modeling procedure, if so justify your viewpoint. CO2 [K₂]
15. A particle or a contaminant is carried by the turbulence in the river flow along the direction of flow. Whether you term is transport phenomenon as Advection or diffusion. CO3 [K₂]
16. A particle or a contaminant is carried along the depth of the river due to turbulence created by the atmospheric temperature. Whether you term is transport phenomenon as Advection or diffusion. CO3 [K₂]

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| 17. | When fresh water from inland moves towards the coastal boundary, whether it can be termed as sea water intrusion, justify your viewpoint. | CO4 | [K ₂] |
| 18. | Whether the depth of the aquifer from the top soil determines the yield that can be drawn, justify your view point. | CO4 | [K ₂] |
| 19. | The results from a numerical model visualize a positive and negative value of same magnitude, and comment on the stability of the model/ scheme. | CO5 | [K ₂] |
| 20. | The topsoil is not fully saturated, comment on the applicability of Darcy equation for computation of the flow velocity. | CO5 | [K ₂] |

PART C (10 x 5 = 50 Marks)

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| 21. | Illustrate the steps / sequence that is associated with model development. | CO1 | [K ₂] |
| 22. | Assume a linear relationship that exists between atmospheric temperature and dissolved oxygen concentration in the river. Illustrate the process of estimating the parameter that exists in the linear model. | CO1 | [K ₃] |
| 23. | Develop a conceptual river water quality model that can simulate the dissolved oxygen in the river. Highlight the assumptions, conditions, governing equation, and other associated terms that required to simulate the intended variable. | CO2 | [K ₃] |
| 24. | Illustrate the influence of Oxygen saturation level in the simulated river dissolved oxygen concentration. | CO2 | [K ₂] |
| 25. | Describe the plug flow reactor. | CO3 | [K ₂] |
| 26. | Classify Plug flow reactor and Mixed flow reactor. | CO3 | [K ₂] |
| 27. | In case you need to simulate the groundwater levels using sparse / few days of monitoring. What will be your preferred method, justify your stand. | CO4 | [K ₃] |
| 28. | In the computation of groundwater levels, whether top soil recharge need to be considered if your area of interest is 50 m below the top soil. Justify your viewpoint. | CO4 | [K ₃] |
| 29. | Assume the continuity equation for a 2D flow, and try to discretize in i) central difference scheme, and ii) Crank-Nicolson scheme. | CO5 | [K ₂] |
| 30. | Discuss on the stability condition with reference to explicit schemes. | CO5 | [K ₂] |

Answer any TWO Questions

PART D (2 x 10 = 20 Marks)

31. Agriculture is believed to be the backbone of Indian GDP growth, in this COVID 19 national shutdown period the yield has reduced due to many unquoted reasons. In a such a situation, the Tamilnadu state government takes a decision to increase the agricultural yield by increasing the percentage of cultivable land. Under this scheme, the water from the Bhavani river is diverted into the Lower Bhavani canal (LBC). The diverted LBC drains into the Noyyal river below orthapalayam dam. On the other hand, River Noyyal is known for its poor water quality. At draining point of LBC into river Noyyal, there is a possibility improvement in river Noyyal water quality due to dilution phenomenon. Your target is to develop a modeling framework to simulate the river Noyyal water quality with respect to time. CO1 & CO2 [K₅]
32. Discuss on the parameters that influence the Dissolved oxygen Simulation equation / model with reference to a case described in Question 31. CO2 [K₃]
33. India is well known for its culture and its diversity, similarly from the monitoring data of IMD it is understood that rainfall pose high variability across the INDIA. As elaborated in the question above (32 a.), agriculture rules INDIA GDP a lot. In this situation of a high demand on agriculture and high variable rainfall, farmers look for various water sources for their survivability. One of such water sources identified by the global farming community is treated / untreated domestic waste water (which is considered to be rich in Nutrients). Africa and India are top leaders in the use of this source of water for agriculture. In such a situation WHO approaches you to develop a model towards understanding the movement of a toxic component in soil-water- plant relationship. Share your views how you approach this problem towards developing a simulation model that mimics the relationship that exists between soil-water and plant. CO5 [K₅]
