KATHMANDU UNIVERSITY
End Semester Examination
January/February 2025

Marks Scored:

Level : B.Sc./B.Tech.
Year : IV

Course : ESEE 403
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date 04 FEB 2025

SECTION "A"
[20Q. × 1 = 20 marks]

Choose the most appropriate answer from the given alternatives and ***encircle****.*

1. You want to know how the changing climate affects the precipitation pattern in the next fifty years. Which type of model will you use?
   a. static, descriptive, and mechanistic
   b. static, predictive, and functional
   c. dynamic, descriptive, and functional
   d. dynamic, predictive, and mechanistic

2. Which method will you use to model the groundwater flow?
   a. Linear reservoir
   b. kinematic wave
   c. Darcy's equation
   d. green-Ampt equation

3. Which type of transport is caused by the flow of the bulk medium?
   a. diffusive transport
   b. dispersive transport
   c. advective transport
   d. multimedia transport

4. A key characteristic of CMFR is:
   a. The effluent concentration is less than that inside the reactor
   b. The effluent concentration is the same as that inside the reactor
   c. The influent concentration is less than that inside the reactor
   d. The influent concentration is the same as that inside the reactor

5. The unit of horizontal dispersion coefficient used in Gaussian plume models is
   a. m/s
   b. m/s^2
   c. m^2/s
   d. m

6. Which model is applicable in the modeling of methane emissions from rice fields?
   a. Tank model
   b. PFR
   c. Gaussian plume model
   d. Monod model

7. In Streeter Phelps model, the concentration of organic pollutants is measured as:
   a. BOD
   b. DOD
   c. DO
   d. COD

8. Which command/function will you use to solve the ODEs in mathematical modeling?
   a. meshgrid
   b. linspace
   c. odeint
   d. array

9. In reactor models used in environmental technologies, what can be achieved by increasing the number of continuously stirred tank reactors?
   a. Cost is reduced
   b. Process becomes less complex
   c. Less construction materials can be used
   d. Increases the performance to meet the treatment objectives

10. Which of the following is part of developing the model but not part of converting your model into a computer model?
    a. Allocate memory to store the variables
    b. Tell the computer how one variable affects another
    c. Fix the parameters
    d. Obtain input variables from the computer user

11. In atmospheric modeling, which of the following is a terrain-following vertical coordinate system?
    a. altitude coordinate system
    b. pressure coordinate system
    c. sigma coordinate system
    d. rectilinear coordinate system

12. The initial evaluation of a model may be carried out by:
    a. Uncertainty analysis
    b. graphical time series analysis
    c. sensitivity analysis
    d. bias analysis

13. Which type of model is best suited to model the hydrology of a small catchment with significant variation in land-use?
    a. Conceptual
    b. lumped
    c. distributed
    d. linear

14. Fugacity is related to
    a. Concentration
    b. concentration gradient
    c. volume
    d. specific volume

15. Which of the following metrics is suitable for quantifying model uncertainties?
    a. Importance index
    b. sample correlation coefficient
    c. lack of fit
    d. root mean square error

16. Which of the following model is the most suitable for climate change modeling?
    a. Gaussian dispersion
    b. GCM
    c. EBM
    d. box

17. In typical environmental modeling research, which type of modeling will use a large number of arrays or grids?
    a. Static
    b. analytical
    c. lumped
    d. distributed

18. According to climate change scenario SSP-4.5, by the end of the century, the temperature is projected to increase by
    a. 1.8°C
    b. 2.7°C
    c. 3.6°C
    d. 4.4 °c

19. Which step in the development of a model will tune the parameters of the model to improve the model performance?
    a. attenuation
    b. calibration
    c. conceptualization
    d. sensitivity analysis

20. According to Fick's Law, the molar rate of transport by diffusion in the x-direction is directly proportional to the
    a. Concentration gradient
    b. volume
    c. pressure difference
    d. temperature gradient

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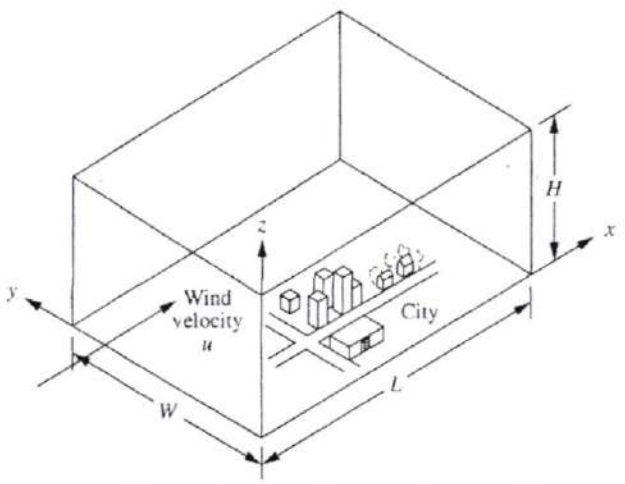
SECTION "B"
[55 marks]

Attempt *ALL* questions. The data or information not given in the questions should be assumed properly.

1. Differentiate between modeling and simulation with specific examples in the field of environmental science and engineering. [5]

2. Differentiate between deterministic and probabilistic models. Use a tabular structure to answer. [4]

3. A small city of Dhulikhel has the following description: W = 5 km, L = 15 km, u = 3 m/s, H = 1000 m. The upwind, or background, concentration of carbon monoxide is b = 5 $\mu g/m^3$. The emission rate per unit area is q = 4 X 10-6 g/s. m^2. *Use metric units for calculation*
   a. What is the concentration of carbon monoxide in the city? [3]
   b. What is the annual average concentration c of carbon monoxide in Dhulikhel City if wind velocity is 3 m/s for 40% of the time and for the remaining 60 percent, the wind blows at right angles to the direction shown in Figure at a velocity of 6 m/s at same mixing height? [4]



4. A country is facing water problems due to climate change. You are asked to assess the problem and recommend solutions based on your assessment.
   a. How will you model climate change and its impact on water sources in terms of water availability? [3]
   b. How will the model output be useful for water resource management in the country? [3]

5. What is the fugacity concept? Provide application of fugacity-based modeling in the field of environmental science and engineering. [2+3]

P.T.O.

6. Provide a specific example of the application of each of the following Python functions to create environmental data: [5]
   a. Array b. linspace c. meshgrid d. hist e. odeint

7. In the context of the hydrological model, differentiate between the lumped and distributed models. Why are semi-distributed models generally used in real applications of hydrological models? [3+2]

8. Define atmospheric models and briefly write about their scales and applications. [2+1+2]

9. A factory emits 20 g/s of $S0_2$ at height H = 30 m. The wind speed is 3 m/s. At a distance of 1 km downwind, the values of horizontal and vertical dispersion coefficients (σ_y and σ_z) are 30 m and 20 m, respectively.
   a. What is the $S0_2$ concentration at the centerline of the plume? [2]
   b. What is the $S0_2$ concentration at a point 60 meters to the side of and 20 meters below the centerline? *use z = H-20* [3]
   Use the following formula to calculate the concentration: c.

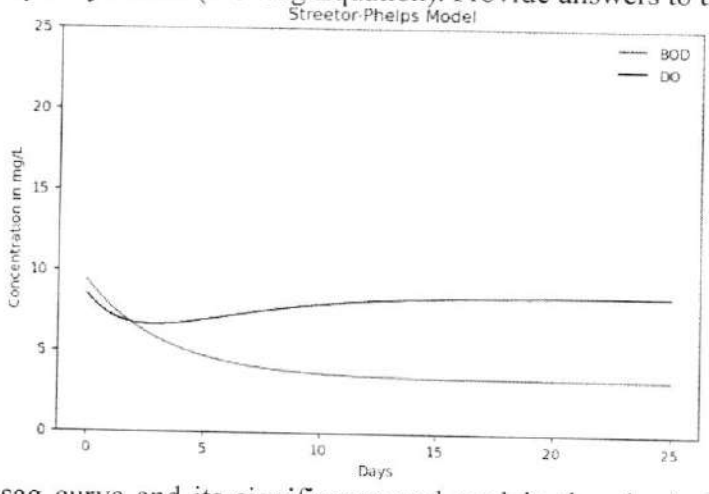
$$\frac{Q}{2\pi u\sigma_y\sigma_z}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right)$$

   c. Explain the significance of the equation given in 7(a) in the context of plume modeling with an explanation for each of the terms in the equation. [3]

OR

Why evaluation is needed in model development? Briefly describe the different types of model evaluations. Write about different quantitative expressions of model sensitivity. [2+3+3]

10. The figure below shows the concentration of DO and BOD with time-based on the Streeter-Phelps River quality model (DO Sag Equation). Provide answers to the following questions.



   a. Discuss the DO sag curve and its significance and explain the physical process of BOD and DO. [3]
   b. What kind of simulation do you expect if you plot BOD and DO along the length of the river? [2]