

KATHMANDU UNIVERSITY
End Semester Examination [C]
May/June, 2019

Marks Scored:

Level : B.Sc./B.Tech.

Year : IV

Exam Roll No. :

Time: 30 mins.

Course : ENVS 404

Semester: I

F. M. : 20

Date : 03 JUN 2019

Registration No.:

SECTION "A"

[20Q. × 1 = 20 marks]

Choose the correct answer from the given options and **encircle** the letter of your choice.

Read this paragraph and answer **Q.1 to Q.4**: "The Weather Research and Forecasting (WRF) model is a numerical weather prediction (NWP) and atmospheric simulation system designed for both research and operational applications. WRF reflects flexible, state-of -the-art, portable code that is efficient in computing environments ranging from massively-parallel supercomputer to laptops. It is suitable for broad span of application across scales ranging from large-eddy to global simulations. Such applications involve real-time NWP, data assimilation development and studies, parameterized physics research, regional climate-simulations, air quality modelling and idealized simulations." (Skamarock et al., 2008).

1. What is the type of application?
a. functional b. dynamic c. static d. mechanistic
2. What is the type of scope?
a. predictive b. descriptive c. static d. dynamic
3. What is the type of inputs?
a. dynamic b. static c. predictive d. descriptive
4. What is the type of outputs?
a. static b. qualitative c. predictive d. quantitative
5. Variables that do not remain constant during the modeling time span are called:
a. attributes b. inputs c. iterators d. parameters
6. Which of the following is suitable for distributed hydrological modeling using numerical techniques?
a. GIS b. AutoCAD c. WRF d. GCM
7. Which visualization plot is good for observing the spatial variation of precipitation in a city?
a. phase b. time series c. box plot d. contour
8. In the soil phase, 5 ppb is:
a. 5 g/kg b. 5 g/g c. 5 mg/kg d. 5 µg/kg
9. Concentration profile for reactions of order one is:
a. $C=C_0-kt$ b. $C=C_0 \exp(-kt)$ c. $C=C_0/(1+C_0kt)$ d. $C=C_0-k$
10. A limited-area model is best described as a:
a. regional climate model b. global-area model
c. local-area model d. neighborhood-scale model

11. A Lagrangian model simulate changes in the chemical composition
 - a. of an air parcel as it is advected in the atmosphere
 - b. of an air parcel filling a room
 - c. of an array of fixed computational cells
 - d. of an array of lakes in series

12. When applying a model to solve air pollution problems, what step should be carried out before using it?
 - a. visualization
 - b. statistical analysis
 - c. validation
 - d. uncertainty analysis

13. Streeter-Phelps model can be used to:
 - a. predict river contamination
 - b. predict air to soil transport
 - c. predict hydrological response
 - d. predict population growth

14. Monod's kinetic model can quantify:
 - a. dissolved oxygen in rivers
 - b. methane emission from paddy field
 - c. stack emission
 - d. multimedia emission

15. A contaminant is decaying due to a first order process. Considering only this decay process, if initial concentration is 120 mg/m^3 and the rate constant is $0.2/\text{day}$, what time will it take in days to reduce this concentration to 10.0 mg/m^3 ?
 - a. 0.08
 - b. 0.5
 - c. 2.5
 - d. 12.4

16. A city is 6 km wide and 25 km long. The mixing height is 1400 m and the average wind speed is 2.5 m/s. If the upwind concentration of a pollutant is $0 \text{ } \mu\text{g/m}^3$, and the emission rate per unit area is $11 \times 10^{-6} \text{ g/s}\cdot\text{m}^2$, what is the concentration of the pollutant over the city in $\mu\text{g/m}^3$?
 - a. 0.00008
 - b. 154
 - c. 78.6
 - d. 7954545

17. Which one of the following models will be the most suitable for mountainous small river basins?
 - a. Kinematic wave
 - b. TOPMODEL
 - c. Richard's equation
 - d. Green-Ampt

18. If the temperature is 500 K, the fugacity capacity of air in $\text{mol/m}^3\text{-Pa}$ is:
 - a. 0.0002
 - b. 0.002
 - c. 0.0166
 - d. 60.1

19. In a compartmental model, which of the following is necessary?
 - a. All parts have same transformation kinetics
 - b. All parts have same transport kinetics
 - c. Different parts have different transformation kinetics
 - d. Different parts have different rates of transport

20. Which one of the following Python libraries can be used to solve an ODE?
 - a. meshgrid
 - b. linspace
 - c. numpy
 - d. scipy

Level : B.Sc./B.Tech.
Year : IV
Time : 2 hrs. 30 mins.

Course : ENVS 404
Semester: I
F. M. : 55

SECTION "B"

Answer *ALL* the 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. Use a tabular structure to answer. [5]
2. You are assigned to model the waste management in a newly proposed municipality in Nepal. It is needed to model according to the specific planning questions under consideration, such as the type of the waste, the growth of the population, the land use scenarios, the capacity constraints and the transportation constraints. Answer the following for this problem:
 - a) Provide different classifications of model that can be applied. [2]
 - b) What steps will you carry out to develop a new model for this problem? [4]
 - c) What techniques will you use to evaluate your new model? [3]
3. The following equation is used for modeling the transport of a species in a fluid system:
$$\frac{\partial C}{\partial t} = E \frac{\partial^2 C}{\partial x^2} - U \frac{\partial C}{\partial x} - kC$$
where C is the concentration of the pollutant, E is the dispersion coefficient, U is the velocity, and k is the reaction rate constant.
 - a) What technique will you use to solve this equation numerically? [2]
 - b) What are the physical meanings of each of the terms in the equation? [2]
 - c) What functions will you use in Python language to visualize the output? [2]
4. Explain the concept of a fugacity-based multimedia model. [4]
5. The air over a region is modeled as a well-mixed box extending horizontally 4500 km in the west-east direction. The box is ventilated by a westerly wind of speed of 8.5 m s^{-1} .
 - a) What is the residence time in days of air in the region? [2]
 - b) An air pollutant is being emitted in the region. Explain the model to model its concentration in the air of the region. [4]
6. A toxic pollutant is being emitted by an industrial stack. The rate of emission of the pollutant is 56 g/s from the effective stack height of 33 m. The average speed of the wind blowing in the region was 4.2 m/s. There was a slightly unstable condition in the atmosphere and the usual dispersion coefficients σ_y and σ_z were 500 m and 300 m respectively at a distance 6 km downwind from the stack.
 - a) Find the concentration of the pollutant along the centerline of the plume at ground level, 6 km downwind from the stack. [4]
 - b) When do you use a virtual mirror image source of the emission? [2]
 - c) In dispersion processes, differentiate between a puff and a plume model. [1]
7. Find the cumulative infiltration after one hour of infiltration into a typical soil that initially had an effective saturation of 35 percent. For the soil, effective porosity is 0.52, wetting front soil suction head is 12.6 cm, and the hydraulic conductivity is 0.58 cm/h. [6]

8. A country is facing the agricultural problems due to climate change. You are asked to assess the problem and recommend solutions based on your assessment.
- a) How will you model the climate change and its impact on agriculture? [3]
 - b) How will you model the water availability? [3]
9. A lake of volume 9×10^{10} L is receiving an inflow of 3000 L/s. A fertilizer is contaminating the drainage basin of the lake, resulting in a load of 500 kg/day to the lake. The first-order decay rate for this fertilizer is 0.19/yr.
- a) Determine the steady-state concentration of the fertilizer in the lake in mg/L. [3]
 - b) Due to a ban on the use of the fertilizer, its inflow declines in the lake according to the equation $W = W_0 \exp(-\mu t)$, where $\mu = 0.03/\text{yr}$ and t is the time in years after the ban. Derive the modified mass balance equation to find the concentration of the fertilizer in the lake. [3]