Take-Home Final Examination

Modeling and Simulation

Due Date: December 16, 2024

Final Examination for Modeling and Simulation

Instructions:

- This is an individual take-home examination.
- Answer all questions comprehensively. Provide detailed explanations, calculations, and diagrams where applicable.
- Submit your answers in a PDF document. Ensure to include your name and student ID on the first page.
- Plagiarism will not be tolerated; all work must be your own.

PART 1: Conceptual Understanding (30 points)

Question 1: (10 points)

Define the following key terms in the context of Modeling and Simulation:

a. Deterministic model

b. Stochastic model

c. Continuous system simulation

d. Discrete-event simulation

e. Monte Carlo simulation

Question 2: (10 points)

Explain the importance of validation and verification in simulation. Provide one example for each to illustrate their roles.

Question 3: (10 points)

Discuss the ethical considerations in using simulations for decision-making. Include at least two examples where misuse of simulations could lead to unethical outcomes.

PART 2: Problem-Solving and Application (40 points)

Question 4: (15 points)

A company is modeling the queue at a customer service desk using a discrete-event simulation. The arrival of customers follows a Poisson distribution with an average rate of 10 customers per hour, and the service time follows an exponential distribution with a mean of 5 minutes.

a. Create a flowchart for this simulation process.

b. Identify at least three performance metrics the company can derive from the simulation.

c. Discuss one strategy to reduce customer waiting time based on the simulation results.

Question 5: (15 points)

Consider a simple predator-prey model described by the Lotka-Volterra equations:

$$\frac{dx}{dt} = \alpha x - \beta xy$$
$$\frac{dy}{dt} = \delta xy - \gamma y$$

where:

- x = prey population
- y = predator population
- $\alpha, \beta, \delta, \gamma$ are positive constants

a. Interpret the meaning of each term in the equations.

b. Using assumed values for $\alpha, \beta, \delta, \gamma$, solve these equations numerically for a time range of 0 to 50. Use Euler's method with a step size of 0.1. (Provide a sample computation for the first 5 steps.)

c. Plot the results and analyze the population dynamics.

Question 6: (10 points)

Explain how simulation can be used to model the spread of infectious diseases. Identify the key parameters and variables involved, and discuss how such simulations can aid in public health decision-making.

PART 3: Case Study (30 points)

Question 7: (30 points)

You are tasked with designing a simulation model for a traffic system in a busy metropolitan area.

a. Identify the objectives of your simulation. (5 points)

b. Describe the key components and assumptions of your model, including the type of simulation you would use (e.g., discrete-event, continuous). (10 points)

c. Propose an approach to validate your model. (5 points)

d. Create a sample output (e.g., a graph, table, or diagram) based on hypothetical data. Analyze this output to draw meaningful conclusions about traffic flow. (10 points)

Matrix of Assessment

Learning Outcome	Question(s)	Cognitive Level	Points
Understand fundamental concepts	1, 2	Remember/Understand	20
Apply modeling techniques	4, 5	Apply/Analyze	30
Analyze simulation outputs	4, 5, 7	Analyze/Evaluate	30
Synthesize and design simulations	7	Create	20
Total	All		**100**