Cairo University
Faculty of Computers and Artificial Intelligence

Term Project

Department: Operations Research and Decision Support
Course Name: Systems Modeling and Simulation **Due Date: December 15th, 2024**
Course Code: DS331/DS241
Instructor: Assoc. Prof. Ayman Ghoneim

General Instructions to Students

- This term *project* is an assessment which contributes to the students' term grades.
- This is a *group* project for *three to four* students per group.
- The programming languages allowed to be used in the research project are Python, C++, or Java.
- Due date (tentative) is December 15th 2024 and Submission procedure and discussions will be announced later.
- For the submitted deliverables, see the end of the document.
- This document has *two* problems, and the group *must attempt both* problems.
- For each problem, it will be stated clearly what implementation is required and/or what should be included in the report.
- *Assessment* will be on the report documentation and code implementation submitted based on the following criteria:
  - The correctness of the algorithms employed and implementation.
  - The quality/comprehensiveness of your experiments & documentation.
  - The correctness of your analysis.
- ***Academic Integrity:*** You can only submit your own work. Any student/group suspected of plagiarism will be subject to the procedures set out in by the Faculty/University (including failing the course entirely). Examples of behaviour that is not allowed are:
  - Copying all or part of someone else's work and submitting it as your own;
  - Giving another student in the class a copy of your work; and
  - Copying parts from the internet, text books, etc.

Problem I [Petrol Station Multi-Channel Queue]

A car belong to one of the following three categories, category A which uses 95 octane petrol, category B which can use both 90 octane or 95 octane petrol, or category C which can use 90 octane petrol or gas. A car belongs to category A with probability 0.2, category B with probability 0.35, and category C with probability 0.45. A petrol station has three pumps, a pump for 95 octane petrol, a pump for 90 octane petrol, and a pump for gas. Cars (regardless of their category) arrive to the petrol station according to the inter-arrival time stated in Table 1. Cars belonging to categories A and B have a service time according to the service-time distribution stated in Table 2, while cars belonging to category C have a service time according to the service-time distribution stated in Table 3. Petrol is more expensive than gas, and 95 octane petrol is more expensive that 90 octane petrol. Drivers want to pay less, however some drivers are in hurry and can go for the more expensive alternative to save time. Meaning, category B cars can go for the 95 octane petrol pump with probability 0.6 if the queue when arriving to the 90 octane petrol pump has more than 3 cars. Similarly, category C cars can go for the 90 octane petrol pump with probability 0.4 if the queue when arriving to the gas pump has more than 4 cars.

Table 1		Table 2		Table 3	
Time between Arrivals (Minutes)	**Probability**	**Category A & B Service Time (Minutes)**	**Probability**	**Category C Service Time (Minutes)**	**Probability**
0	0.17	1	0.20	3	0.20
1	0.23	2	0.30	5	0.50
2	0.25	3	0.50	7	0.30
3	0.35				

Using the discrete event simulation approach, the problem is to estimate the system measures of performance in terms of the following:

1- The average service time of cars in the three categories.
2- The average waiting time in the queues for each pump, and the average waiting time for all cars.
3- The maximum queue length for each pump.
4- The probability that a car wait for each pump.
5- The portion of idle time of each pump.

Moreover, the policy maker requires answers for the following questions:

6- Does the theoretical average service time of the service time distribution match with the experimental one for the three categories?
7- Does the theoretical average inter-arrival time of the inter-arrival time distribution match with the experimental one?
8- If the petrol station is investigating the addition of one extra pump, what kind of pump (95 octane, 90 octane or gas) will result in the most decrease in the average waiting time for all cars?

<u>**Assessments Marking Criteria**</u>

<u>**Problem I - The Pertol Station**</u>

Simulation Project			
Report Components	Part 1 • Problem formulation & Objectives.	2	25
	Part 2 • System Components. • System analysis including cumulative distribution tables, simulation table (for 20 cars).	2 8	
	Part 3 • Experimental Design Parameters • Justification of experiment parameters values	2 2	
	Part 4 • Results Analysis: Using graphs & discussions stating the results for the 8 questions. • Conclusion	9	
Simulation Program	Coding Style (naming convention, comments)	6	22
	GUI and Data Visualization (graphs)	4	
	Correct computation and results for • The average service time of cars in the three categories. • The average waiting time in the queues for each pump, and the average waiting time for all cars. • The maximum queue length for each pump. • The probability that a car wait for each pump. • The portion of idle time of each pump. • If the petrol station is investigating the addition of one extra pump, what kind of pump (95 octane, 90 octane or gas) will result in the most decrease in the average waiting time for all cars?	2 2 2 2 2 2	
Extra features in the simulator (for example: generic or extra statistics)			3
Total			**50**

Problem II [Hospital Inventory System]

A hospital has a main basement inventory and a first floor inventory. The inventory in the first floor serves five patients' rooms, where each room consumes one box of medical supplies per day. The first floor inventory has a maximum capacity of 10 medical supplies boxes, while the basement inventory has a maximum capacity of medical supplies 30 boxes. Every day, there are number of rooms occupied by patients according to the distribution shown in Table 1. When the first floor inventory runs out of boxes, it sends a request for the basement inventory to receive a new 10 boxes, and it receives instantaneously the 10 boxes or less according to the boxes availability in the basement inventory. Frequently, the hospital places an order to fill the basement inventory to its maximum limit. The lead time is the time from placement of an order by the hospital to receive new lot of boxes until the order is received. Here, lead time in days is a random variable, as shown in Table 2. During the lead time, the first floor inventory still may require boxes. It is assumed that orders are placed at the close of business and are received for inventory at the beginning of business day as determined by the lead time. The review period (i.e., the period after which the inventory is revised and an order is placed to fill the inventory to its maximum limit) is denoted by variable N = 6.

Table 1

# of Rooms Occupied	Probability
1	0.1
2	0.15
3	0.35
4	0.2
5	0.2

Table 2

Lead Time	Lead Time Probabilities
1	0.4
2	0.35
3	0.25

Assuming that the basement inventory has already 30 boxes, and the first floor inventory already has 4 boxes, the policy maker wants to investigate the following.

1- The average ending units in first floor inventory and the basement inventory.
2- The number of days when a shortage condition occurs.
3- Does the theoretical average demand of boxes match the experimental one?
4- Does the theoretical average lead time of the lead time distribution match the experimental one?
5- Is there a better value for the review period variable N to minimize the shortages of medical supplies boxes?
6- Is there a better value for the maximum capacity M of the basement inventory to minimize the shortages of medical supplies boxes?

Assessments Marking Criteria
Problem II – Hospital Inventory System

Simulation Project			
Report Components	Part 1 • Problem formulation & Objectives.	2	25
	Part 2 • System Components. • System analysis including cumulative distribution tables, simulation table (for 20 days).	2 8	
	Part 3 • Experimental Design Parameters • Justification of experiment parameters values	2 2	
	Part 4 • Results Analysis: Using graphs & discussions stating the results for the 5 questions. • Conclusion	9	
Simulation Program	Coding Style (naming convention, comments)	6	22
	GUI and Data Visualization (graphs)	4	
	Correct computation and results for • The average ending units in first floor inventory and the basement inventory. • The number of days when a shortage condition occurs. • Does the theoretical average demand of boxes match the experimental one? • Does the theoretical average lead time of the lead time distribution match the experimental one? • Is there a better value for the review period variable N to minimize the shortages of medical supplies boxes? • Is there a better value for the maximum capacity M of the basement inventory to minimize the shortages of medical supplies boxes?	2 2 2 2 2 2	
Extra features in the simulator (for example: generic or extra statistics)			3
Total			**50**

Deliverables

One compressed file which must include a report documentation (Word or PDF file) and code implementation files, following the below details.

- Report documentation including:
    - Cover Sheet: Includes the CU and FCAI logos, course code, course name, problem title, group members (name and ID).
    - Table of Contents
    - Each requirement in the problem. Your report must be organized following the same organization of requirements and marking criteria stated here in the document.

- Code Implementation files, where each file is named after the part it corresponds to. For example, Problem I. The code file can be included in a folder (e.g., Problem I) if you are using several implementation code files.

Good Luck ☺