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 23rd, 2023**
Course Code: DS331/DS241
Instructor: Assoc. Prof. Ayman Ghoneim

General Instructions to Students

- This term *project* is a partial substitute assessment for the midterm unseen written exam.
- 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 or Java.
- Due date is December 23rd 2022 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 [Supermarket Multi-Channel Queue]

The checkout area of a supermarket has one express cashier who can serve customers with 12 items or less, and a regular cashier who can serve any customer regardless of the number of items bought. Both cashiers have the same service efficiency and enough space (i.e., a queue) to accommodate all waiting customers. When a regular customer (has more than 12 items) arrives to the checkout area, the customer joins the regular cashier's queue. However, when an express customer (has 12 items or less) arrives to the checkout area, the customer joins the express cashier's queue only if the express cashier's queue length is less than 1.5 times the regular cashier's queue length. Express customers represent 60% of the customers, while 40% of the customers are regular customers. The time between customers' arrivals to the checkout area (Table 1) and service-time distributions of express customers (Table 2) and regular customers (Table 3) are given below.

Table 1

Time between Arrivals (Minutes)	Probability
0	0.16
1	0.23
2	0.30
3	0.21
4	0.1

Table 2

Express Customers Service Time (Minutes)	Probability
1	0.30
2	0.40
3	0.30

Table 3

Regular Customers Service Time (Minutes)	Probability
3	0.20
5	0.50
7	0.30

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 the express customers and the regular customers.
2- The average waiting time in the express cashier queue and the regular cashier queue.
3- The maximum express cashier queue length and regular cashier queue length.
4- The probability that a customer wait in the express cashier queue.
5- The portion of idle time of the express cashier and regular cashier.

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 both types of customers?
7- Does the theoretical average inter-arrival time of the inter-arrival time distribution match with the experimental one?
8- How does using a different percentage of both types of customers (for example, 40% express customers and 60% regular customers) affect the system?

Assessments Marking Criteria
Project 1 - The Supermarket

	Simulation Project		
Report Components	Part 1 • Problem formulation & Objectives.	2	25
	Part 2 • System Components. • System analysis including cumulative distribution tables, calendar table (for 10 customers).	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, OOP)	6	22
	GUI and Data Visualization (graphs)	4	
	Correct computation and results for • The average service time of the express customers and the regular customers. • The average waiting time in the express cashier queue and the regular cashier queue. • The maximum express cashier queue length and regular cashier queue length. • The probability that a customer wait in the express cashier queue. • The portion of idle time of the express cashier and regular cashier. • How does using a different percentage of both types of customers (for example, 40% express customers and 60% regular customers) affect the system?	2 2 2 2 2	
	Extra features in the simulator (for example: generic or extra statistics)		3
Total			**50**

Problem II [Car Dealer]

A car dealer has a car display showroom (i.e., for customers to closely inspect the car and its options) that can hold a maximum of 5 cars. Further, there is an inventory that holds a maximum of 10 cars. Every day there is a demand on cars where the distribution of the number of cars demanded per day is shown in Table 1. The cars are sold first from the inventory, and when the inventory runs out of cars, the cars in the showroom are sold. Frequently, the car dealer places an order to fill the inventory and the showroom to their maximum limit. When the order arrives, the show room is filled to its maximum first then the inventory after that. The lead time is the time from placement of an order by the car dealer to receive new lot of cars until the order is received. Here, lead time is a random variable, as shown in Table 2. During the lead time, demands also occur at random. 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 = 3. The net profit of selling one car is 10,000 LE, the holding expenses for one car per day is 1000 LE, and the cost of making and shipping an order is 20,000 LE. If there are no cars to meet a certain demand, then this is considered a lost opportunity.

Table 1

Demand	Demand Probabilities
0	0.2
1	0.34
2	0.36
3	0.1

Table 2

Lead Time	Lead Time Probabilities
1	0.4
2	0.35
3	0.25

Assuming that the inventory has already 3 cars, the showroom already has 4 cars, and there is an order placed with 5 cars scheduled to arrive after 2 days, the policy maker wants to investigate the following.

1- The average ending units in showroom and the inventory.
2- The number of days when a shortage condition occurs.
3- The average net profit for the car dealer.
4- Does the theoretical average demand of the demand distribution match the experimental one?
5- Does the theoretical average lead time of the lead time distribution match the experimental one?
6- Is there a better value for the review period variable N to maximize the car dealer net profit?

Assessments Marking Criteria
Project 2 - The Car Dealer

Simulation Project			
Report Components	Part 1 • Problem formulation & Objectives.	2	25
	Part 2 • System Components. • System analysis including cumulative distribution tables, calendar table (for 10 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, OOP)	6	22
	GUI and Data Visualization (graphs)	4	
	Correct computation and results for • The average ending units in showroom and the inventory. • The number of days when a shortage condition occurs. • The average net profit for the car dealer. • Does the theoretical average demand of the demand distribution 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 maximize the car dealer net profit?	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 ☺