Cairo University
Faculty of Computers and Artificial Intelligence

Term Project

Department: Operations Research and Decision Support
Course Name: Systems Modeling and Simulation **Due Date: January 3rd, 2022**
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 *up to* three students per group.
- The programming languages allowed to be used in the research project are Python or Java.
- Due date is January 3rd 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 [Bank Multi-Channel Queue]

A bank has one drive-in teller (who can serve customers without leaving their cars). The drive-in teller has a room (i.e., a queue) for one additional customer to wait. Customers arriving when the drive-in teller queue is full will park their cars and go inside the bank to transact business. Inside the bank, the waiting area is sufficient to accommodate all customers, and there is one teller who is as efficient as the drive-in teller in terms of serving the customers. The time-between-arrivals and service-time distributions are given below in tables 1 and 2, respectively.

Table 1

Time between Arrivals (Minutes)	Probabilities
0	0.09
1	0.19
2	0.30
3	0.21
4	0.12
5	0.09

Table 2

Service Time (Minutes)	Probabilities
1	0.20
2	0.40
3	0.28
4	0.12

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 drive-in teller and the inside-bank teller.
2- The average waiting time in the drive-in teller queue and the inside-bank teller queue.
3- The maximum inside-bank teller queue length.
4- The probability that a customer wait in the inside-bank teller queue.
5- The portion of idle time of the inside-bank teller.

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?
7- Does the theoretical average inter-arrival time of the inter-arrival time distribution match with the experimental one?
8- If the drive-in teller queue can accommodate for two cars instead of one car, how does this affect the average waiting time in the drive-in teller queue and the inside-bank teller queue.

Assessments Marking Criteria
Problem 1 - The Bank

The Bank 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 drive-in teller and the inside-bank teller. • The average waiting time in the drive-in teller queue and the inside-bank teller queue. • The maximum inside-bank teller queue length. • The probability that a customer wait in the inside-bank teller queue. • The portion of idle time of the inside-bank teller. • If the drive-in teller queue can accommodate for two cars instead of one car, how does this affect the average waiting time in the drive-in teller queue and the inside-bank teller queue?	2 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.

Table 1

Demand	Demand Probabilities
0	0.04
1	0.30
2	0.36
3	0.16
4	0.14

Table 2

Lead Time	Lead Time Probabilities
1	0.5
2	0.35
3	0.15

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- Does the theoretical average demand of the demand distribution 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 shortage?

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 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 5 questions. • Conclusion	9	
Simulation Program	Coding Style (naming convention, comments, OOP)	6	20
	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. • 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 minimize the shortage?	2 2 2 2 2	
Extra features in the simulator (for example: generic or extra statistics)			5
		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 ☺