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, 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 *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 [Bank Multi-Channel Queue]

A bank has one teller who can serve customers. Customers are divided into two types, ordinary and distinguished customers, where each type has a separate queue. The time between arrivals and the service time for the ordinary customers are as shown in table 1, while the time between arrivals and the service time for the distinguished customers are as shown in table 2. The distinguished customers have a higher priority to be served, i.e., a waiting distinguished customer will be served before a waiting ordinary customer. However, the service of an ordinary customer cannot be interrupted by the arrival of an distinguished customer.

Table 1: Ordinary Customer

Time between Arrivals (Minutes)	Probabilities	Service Time (Minutes)	Probabilities
0	0.09	1	0.20
1	0.17	2	0.40
2	0.27	3	0.28
3	0.20	4	0.12
4	0.15		
5	0.12		

Table 2: Distinguished Customer

Time between Arrivals (Minutes)	Probabilities	Service Time (Minutes)	Probabilities
1	0.1	1	0.10
2	0.2	2	0.30
3	0.3	3	0.38
4	0.4	4	0.22

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 teller.
2- The average waiting time in the ordinary customers queue and the distinguished customers queue.
3- The maximum ordinary customers queue length and the distinguished customers queue length.
4- The probability that an ordinary customer wait in the queue, and the probability that a distinguished customer wait in the queue.
5- The portion of idle time of the 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 for both types of customers?

7- Does the theoretical average inter-arrival time of the inter-arrival time distribution match with the experimental one for both types of customers?
8- If there is an additional teller to serve the distinguished customers only, how does this affect the average waiting time in the queues of both types of customers?

Assessments Marking Criteria
Problem I - The Bank

	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 teller. • The average waiting time in both queues. • The maximum for both queues. • The probability that an ordinary customer and a distinguished customer wait in the queue. • The portion of idle time of the teller. • If there is an additional teller to serve the distinguished customers only, how does this affect the average waiting time in the queues of both types of customers?	2 2 2 2 2 2	
Extra features in the simulator (for example: generic or extra statistics)			3
Total			**50**

Problem II [Newspapers Seller]

Newspapers seller buys the newspaper with 50 cents each and sells them for 70 cents each. Newspapers not sold at the end of the day are sold as scrap for 15 cents each. Newspapers can be purchased in bundles of 20. Thus, the seller can buy 40, 60, and so on. There are three types of Newsday, "Excellent", "good", "fair", and "poor" with probabilities of 0.18, 0.42, 0.32, and 0.08 respectively. The distribution of papers demanded on each of these days is given in the table below.

Distribution of Newspapers demanded

Distribution of Newspapers Demanded				
Demand	Demand Probabilities			
	Excellent	Good	Fair	Poor
40	0.00	0.06	0.15	0.42
50	0.07	0.09	0.22	0.28
60	0.08	0.16	0.28	0.14
70	0.12	0.19	0.18	0.10
80	0.13	0.28	0.10	0.05
90	0.22	0.12	0.05	0.01
100	0.23	0.07	0.02	0.00
110	0.08	0.03	0.00	0.00
120	0.07	0.00	0.00	0.00

Assumption: the profits are given by the following relationship:

Profit = [(revenue from sales) – (cost of newspapers) – (lost profit from excess demand) + (salvage from sale of scrap papers)]

The problem is to answer the following questions:

1- Determine the optimal number of papers the seller should purchase to increase his profit.
2- How does the price of selling the newspaper and of selling the unsold newspapers as a scrap affect your answer (the optimal number to purchase) in the previous question (1)?
3- How does the size of bundle used to purchase newspapers affect your answer (the optimal number to purchase) in the previous question (1)?

Assessments Marking Criteria
Project II - The Newspapers Seller

Simulation Project			
Report Components	Part 1 • Problem formulation & Objectives.	2	26
	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 3 questions. • Conclusion	10	
Simulation Program	Coding Style (naming convention, comments, OOP)	6	21
	GUI and Data Visualization (graphs)	4	
	Correct computation and results for • Determine the optimal number of papers the seller should purchase to increase his profit. • How does the price of selling the newspaper and of selling the unsold newspapers as a scrap affect your answer (the optimal number to purchase) in the previous question (1)? • How does the size of bundle used to purchase newspapers affect your answer (the optimal number to purchase) in the previous question (1)?	3 5 3	
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 ☺