University of Chittagong

Department of Computer Science and Engineering

7th Semester B.Sc. (Engineering) Examination 2022

Course Title: Modeling and Simulation

Course No. CSE 719, Full Marks: ***, Time: *** Hours

Assignment 1 / Tutorial 1 : Answer *** questions as guideline

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Chapter 1

1. Define Simulation and Modeling.
2. Define the following:
   i) System State and ii) Environment
3. When Simulation Is the Appropriate Tool and Not Appropriate?
4. Write down the advantages and disadvantages of simulation.
5. Describe the Areas of Application of Simulation.
6. Illustrate the classification of models.
7. Differentiate between Discrete and Continuous System with necessary diagrams.
8. Discuss the characteristics of Discrete-Event System Simulation.
9. Differentiate between Stochastic, Dynamic and Discrete-event system.
10. Explain the steps in simulation study with appropriate diagram.

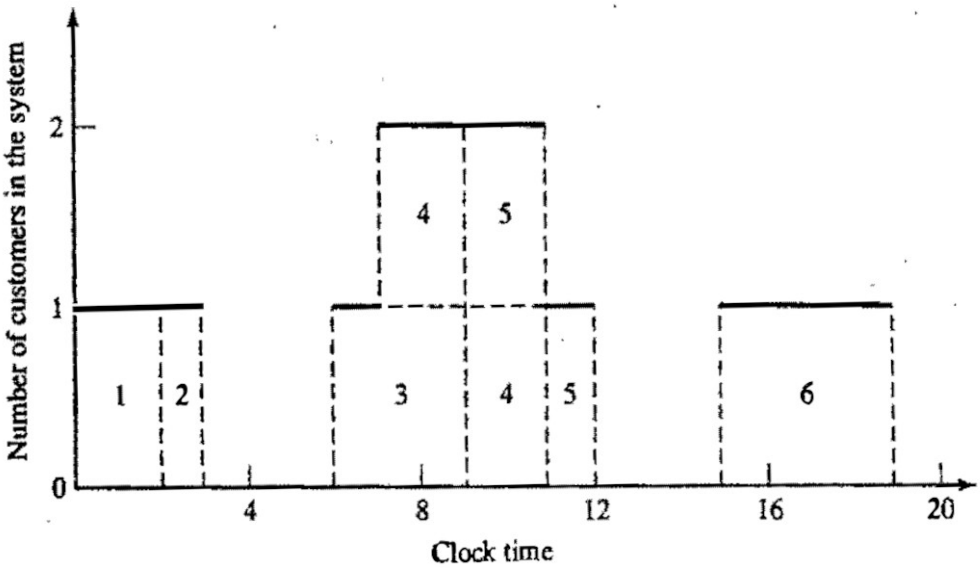
Chapter 2

11. Consider the customers in the single server queueing system simulation (as in table 2.10). Sketch up the step by step actions for (a) Service just completed and (b) Unit entering system using flow diagram.
12. Consider the customers in the duel server queueing system simulation (as in table 2.14). Sketch up the step by step actions for (a) Service just completed and (b) Unit entering system using flow diagram.
13. Find out the "Probability" and "Cumulative Probability" in the following table of Distribution of Travel Time for some Dump Trucks.

Travel time	Probability	Cumulative Probability	Random Number
110			01-35
130			36-75

170			71-90
180			91-00

14. Consider the 6 customers in the single server queueing system simulation in table 2.4 in the textbook. Calculate the following criteria.
    i) Percentage of customer waited in the queue and server utilization
    ii) Average time spent in system and in queue per customer
    iii) Average interarrival time and service time
    iv) Expected interarrival time and service time
    v) Varience and Standard deviation of interarrival time and service time
    vi) Average number of customers in system and in queue
    vii) Standard deviation and average waiting time of those who waited
    viii) Variance and coefficient of variance of system time
15. Consider the available customers in the single server queueing system simulation in table 2.10 in the textbook. Calculate the above criteria.
16. Consider the available customers in the single server queueing system simulation in table 2.14 in the textbook. Calculate the above criteria.
17. Consider the 6 customers in the single server queueing system simulation in figure 2.6 in the textbook.



Calculate the above criteria.

18. Consider the available customers in the single server queueing system simulation in figure 6.6 in the textbook. Calculate the above criteria.
19. Consider the available customers in the single server queueing system simulation in figure 6.11 in the textbook. Calculate the above criteria.
20. Consider the grocery shop single server queueing system simulation. The time between arrival of the customers ranges from 1 to 8 minutes, with uniform

distribution.
The probability distributions of the service time are shown in the following Table.

Service Time (Minutes)	Probability
1	0.10
2	0.20
3	0.30
4	0.25
5	0.10
6	0.05

Consider twenty customers with uniformly distributed random numbers (Appendix Table A.1 in the textbook) for both interarrival and service time simulation. Calculate the above criteria.

21. Consider a computer technical support center where two technical support people — Able and Baker take calls and provide service. The time between calls ranges from 1 to 4 minutes, with distribution as shown in the following table.

Call Interarrivals (Minutes)	Probability
1	0.25
2	0.40
3	0.20
4	0.15

Able is more experienced and can provide service faster than Baker. The distributions of their service times are shown in the following Table.

Able		Baker	
Service Time (Minutes)	Probability	Service Time (Minutes)	Probability
2	0.30	3	0.35
3	0.28	4	0.25
4	0.25	5	0.20
5	0.17	6	0.20

Able gets the call if both technical support people are idle. Consider twenty customers with random number Appendix Table A.1 in the textbook for both interarrival and service time simulation. Calculate the above criteria.

22. Consider 6 customers of the single server queueing system simulation in the table 2.4 in the text book. Draw the graph ‘Time’ vs ‘Number of customer in system’ from that.

23. Consider 20 customers of the single server queueing system simulation in the table 2.10 in the text book (or the following table).

Customer	Time Since Last Arrival (Minutes)	Arrival Time	Service Time (Minutes)	Time Service Begins	Time Customer Waits in Queue (Minutes)	Time Service Ends	Time Customer Spends in System (Minutes)	Idle Time of Server (Minutes)
1	—	0	4	0	0	4	4	0
2	8	8	1	8	0	9	1	4
3	6	14	4	14	0	18	4	5
4	1	15	3	18	3	21	6	0
5	4	19	2	21	2	23	4	0

Draw the graph ‘Time’ vs ‘Number of customer in system’ from that.

24. Consider 5 customers of the duel server queueing system simulation in the table 2.14 in the text book. Draw the graph ‘Time’ vs ‘Number of customer in system’ from that.

25. Consider the available customers of the single server queueing system simulation in the table 3.2 in the text book. Draw the graph ‘Time’ vs ‘Number of customer in system’ from that.

26. Construct a table (sample as table 2.10 and 2.14 in textbook) with ***CustomerID, Interarrival time, Arrival-Time, When-Server-Available, Server-Chosen, Service-Time, Time-Service-Begins, Waiting-Time-in-Queue, Time-Service-Ends, Time-Customer-Spends-in-System, Server-Idle-Time*** for the customers in the queueing system in the table 3.2 in the textbook.

27. Construct the above table for the customers in the queueing system in the figure 2.6 in the textbook.

28. Construct the above table for the customers in the queueing system in the figure 6.6 in the textbook.

29. Construct the above table for the customers in the queueing system in the figure 6.11 in the textbook.

30. A classical inventory problem concerns the purchase and sale of newspapers. The newsstand buys the newspapers for 33 cents each and sells them for 50 cents each. Newspapers not sold at the end of the day are sold as scrap for 5 cents each. Newspapers can be purchased in bundles of 10. Thus, the newsstand can buy 50, 60, and so on. There are three types of news-days:

"good"; "fair"; and "poor"; they have the probabilities 0.35, 0.45, and 0.20 respectively. The distribution of newspapers demanded on each of these days is given in table i. Table ii shows part of simulation table for Purchase of 70 Newspapers. Find out the total profit after 20 days.

Table i: Distribution of Newspapers Demanded Per Day

Demand	Demand Probability Distribution		
	Good	Fair	Poor
40	0.03	0.10	0.44
50	0.05	0.18	0.22
60	0.15	0.40	0.16
70	0.20	0.20	0.12
80	0.35	0.08	0.06
90	0.15	0.04	0.00
100	0.07	0.00	0.00

Table ii: Simulation Table for Purchase of **70** Newspapers

Day	Random Digits for Type of Newsday	Type of News-day	Random Digits for Demand	Demand
1	58	Fair	93	80
2	17	Good	63	80
3	21	Good	31	70
4	45	Fair	19	50
5	43	Fair	91	80
6	36	Fair	75	70
7	27	Good	84	90
8	73	Fair	37	60
9	86	Poor	23	40
10	19	Good	02	40
11	93	Poor	53	50
12	45	Fair	96	80
13	47	Fair	33	60
14	30	Good	86	90
15	12	Good	16	60
16	41	Fair	07	40
17	65	Fair	64	60
18	57	Fair	94	80
19	18	Good	55	80
20	98	Poor	13	40

31. Consider a refrigerators selling company who maintains inventory to review the situation after a fixed number of days (say N or one cycle) and make a decision about what is to be ordered up to a level (the order up to level-say, M), using the following relationship:
Order quantity = (Order-up-to level) - (Ending inventory) + (Shortage quantity)

The lost sales case occurs when customer demand is lost if the inventory is not available. In the textbook, the number of refrigerators ordered each day is randomly distributed as shown in Table 2.19. Another source of randomness is the number of days after the order is placed with the supplier before arrival, or lead time. The distribution of lead time is shown in Table 2.20. The simulation has been started with the inventory level at 3 refrigerators and an order for 8 refrigerators to arrive in 2 days' time.

i) Construct the simulation table as shown in Table 2.21.

ii) Find out the average ending inventory, average demand and average shortage quantity

iii) Discuss the significant factors to improve the system

32. A milling machine has three different bearings that fail in service. The distribution of the life of each bearing is given (Bearing-Life-Time-Hour, Probability): (1000, 0.1); (1100, 0.13); (1200, 0.25); (1300, 0.13); (1400, 0.09), (1500, 0.12); (1600, 0.02); (1700, 0.06); (1800, 0.05); (1900, 0.05). When a bearing fails, the mill stops, a Repair-person is called who installs a new bearing (costing $32 per bearing). The delay time for the Repair-person to arrive varies randomly, having the distribution given (Delay-Time-Minutes, Probability): (5, 0.6); (10 0.3); (15, 0.1). Downtime for the mill is estimated to cost $10 per minute. The direct on-site cost of the Repair-person is $30 per hour. The Repair-person takes 20 minutes to change one bearing, 30 minutes to change two bearings, and 40 minutes to change three bearings. The mill-engineering-staff has proposed a new policy to replace all three bearings whenever one bearing fails. Management needs an evaluation of the proposal, using total cost as the measure of performance. The Bearing-Life-Time-Hour and delay of 15 bearing changes for the current policy (policy 1 or model 1), shown in the following table.

Step	Bearing 1		Bearing 2		Bearing 3	
	Life (Hours)	Delay (minutes)	Life (Hours)	Delay (minutes)	Life (Hours)	Delay (minutes)
1	1100	5	1700	15	1800	15
2	1200	5	1100	10	1600	5
3	1100	10	1200	5	1000	10
4	1300	5	1300	15	1200	5
5	1400	15	1500	5	1200	5

The Bearing-Life-Time-Hour and delay of 15 bearing changes for the proposed policy (Policy-2 or model 2), shown in the following table.

Step	Bearing 1	Bearing 2	Bearing 3	First	Delay

	Life (Hours)	Life (Hours)	Life (Hours)	Failure (Hours)	(minutes)
1	1000	1500	1300	1,000	10
2	1600	1100	1100	1,100	5
3	1200	1300	1700	1,300	5
4	1400	1700	1200	1,200	5
5	1800	1800	1200	1,200	15

Find out the followings for both policies: ***Total Number of Bearings***, ***Total Delay Time*** (minutes), ***Total Repair Time*** (minutes), ***Cost of Bearings***, ***Cost of Delay Time***, ***Cost of Downtime During Repair***, ***Cost of Repair-person*** and ***Total Cost***. Based on ***Total Cost***, which policy is better?

33. Consider a bomber (fighter plane) attempting to destroy an ammunition depot as shown in figure 2.15 in the textbook. The bomber has conventional rather than laser-guided weapon. If a bomb falls anywhere on the target, a hit is scored otherwise, the bomb is a miss. The bomber flies in the horizontal direction and carries 10 bombs. The aiming point is (0,0). The point of impact is assumed to be normally distributed around the aiming point with a standard deviation of 400 meters in the direction of flight and 200 meters in the perpendicular direction. Construct the simulation table as shown in table 2.26 and find out the number of hits out of attempts.

34. Explain the "Activity Network" with diagram and example.

Chapter 3

35. Discuss Event, Event-Notice, Future-Event-List, System, System-Environment, Attribute, Activity and State with respect to the simulation.

36. Name entities, attributes, activities, events, and state variables for the following systems: (a) University library, (b) Financial Bank, (c) Call center, (d) Hospital blood bank, (e) Departmental store, (f) Fire service station, (g) Airport, and (b) Software organization.

37. Describe the definition and categories of World Views in simulation.

38. What are event scheduling, activity scanning and bootstrapping? Give example.

39. Consider the 6 customers in the single server queueing system simulation in the following table.

Cloc	**System State**	**Checkout Line**	**Future Event List**

k	LQ (t)	LS (t)		
0	0	1	(C1,O)	(A,1,C2) (D,4,C1) (E,23)
1	1	1	(C1,O) (C2,1)	(A,2,C3) (D,4,C1) (E,23)
2	2	1	(C1,0) (C2,1) (C3,2)	(D,4,C1) (A,8,C4) (E,23)
4	1	1	(C2,1) (C3,2)	(D,6,C2) (A,8,C4) (E,23) ·
6	0	1	(C3,2)	(A,8,C4) (D,11,C3) (E,23)
8	1	1	(C3,2) (C4,8)	(D,11,C3) (A,11,C5) (E,23)
11	1	1	(C4,8) (C5,11)	(D,15,C4) (A,18,C6) (E,23)
15	0	1	(C5,11)	(D,16,C5) (A,18,C6) (E,23)
16	0	0	* * * *	(A,18,C6) (E,23)
18	0	1	(C6,18)	(D,23,C6) (E,23)
23	0	1	* * * *	* * * *

Calculate the following:
i) Percentage of customer waited in the queue and server utilization
ii) Average time spent in system and in queue per customer
iii) Average interarrival time and service time
iv) Expected interarrival time and service time
v) Varience and Standard deviation of interarrival time and service time
vi) Average number of customers in system and in queue
vii) Standard deviation and average waiting time of those who waited
viii) Variance and coefficient of variance of system time
ix) Maximum queue length and Sum of customer response time
x) Total number of customers who spend 5 or more minutes in the system
xi) Total number of departures

40. Construct a table (sample as table 3.1 and 3.2 in textbook) with ***Clock, Queue-State, Server-State***, ***Future-Event-List, Busy-Time*** *and* ***Maximum-Queue-Length, Departed-Customers-Response-Time, Number-of-Customers-who-spend-Four-or-More-Minutes, and Total-Departures*** for the customers in the single server queueing system in the following simulation table.

Customer Number	**Arrival Time**	**Time Service Begins**	**Time Service Ends**

	(clock)	(clock)	(clock)
1	0	0	2
2	2	2	3
3	6	6	9
4	7	9	11
5	9	11	12
6	15	15	19

41. Consider the table 2.10 in the text book (or the following table).

Table : Simulation Table for Grocery Store Queueing Problem								
Customer	Time Since Last Arrival (Minutes)	Arrival Time	Service Time (Minutes)	Time Service Begins	Time Customer Waits in Queue (Minutes)	Time Service Ends	Time Customer Spends in System (Minutes)	Idle Time of Server (Minutes)
1	—	0	4	0	0	4	4	0
2	8	8	1	8	0	9	1	4
3	6	14	4	14	0	18	4	5
4	1	15	3	18	3	21	6	0
5	4	19	2	21	2	23	4	0

Construct the required (***Future-Event-List***) table in the above question from that.

42. Consider the table 2.14 in the text book. Construct the required (***Future-Event-List***) table in the above question from that.

43. Consider the figure 2.6 in the text book. Construct the required (***Future-Event-List***) table in the above question from that.

44. Consider the figure 6.6 in the text book. Construct the required (***Future-Event-List***) table in the above question from that.

45. Consider the figure 6.11 in the text book. Construct the required (***Future-Event-List***) table in the above question from that.

46. Construct a table (sample as table 2.10 and 2.14 in textbook) with ***CustomerID (TruckNumber), Interarrival time, Arrival-Time, When-Server-Available, Server-Chosen, Service-Time, Time-Service-Begins, Waiting-Time-in-Queue, Time-Service-Ends, Time-Customer-Spends-in-System, Server-Idle-Time*** for the Dump-Truck Operction queueing system simulation in the table 3.6 in the textbook.
Calculate the following:
i) Average loader utilization
ii) Average scale utilization

47. Construct the Future Event List Table (Table 3.6) for the Dump Truck

simulation.

48. Write down the properties and operations of Lists in simulation.

49. Describe the different strategies of List Processing with their merits and demerits.

Chapter 4

50. Mention the main characteristics with time period of the generations of development of simulation softwares.

51. Explain the features in different categories during the selection of simulation software.

52. Narrate the seven advices when evaluating and selecting simulation software.

53. Illustrate the flow chart of overall structure of Java implementation of the simulation of a single-server queueing model.

54. Describe the criteria for selecting a software for simulation.

55. Write a program in any computer programming language for the grocery checkout counter (single server queueing model) simulation as defined in detail in table 2.10 in the textbook. The total number of customers to be served should be an input from the user of this program.

56. Make the necessary modifications to the above computer program of model of the checkout counter (Example 4.2) so that the simulation will run for exactly 60 hours.

57. Make the necessary modifications to the above computer program of model of the checkout counter (Example 4.2) so that an arriving customer does not join the queue if three or more customers are waiting for service.

58. Illustrate the source code in the class method ProcessArrival in Java programming language, which is called to process each arrival event for a single-server queueing system simulation.
    Hint: First, the new arrival is added to the queue-Customers in the system. Next, if the server is idle (LS or NumberInService == 0) then the new customer is to go immediately into service, so sim class method ScheduleDeparture is called to do that scheduling. An arrival to an idle queue (LQ or QueueLength = 0) does not update the cumulative statistics, except possibly the maximum queue length. An arrival to a busy queue does not cause the scheduling of a departure, but does increase the total busy time by the amount of simulation time between the current event and the one immediately preceding it (because, if the server is busy now, it had to have at least one customer in service by the end of processing the previous event). In either case, a new arrival is responsible for scheduling the next arrival, one random interarrival time into the future. An arrival event is created with simulation

time equal to the current Clock value plus an exponential increment, that event is inserted into the future event list, the variable LastEventTime recording the time of the last event processed is set to the current time, and control is returned to the main method of class Sim.

59. Illustrate the source code in the class method ProcessDeparture in Java programming language, which is called to process each departure event for a single-server queueing system simulation.

60. Discuss the application-area, features and history of different simulation packages.