Homework 1: Simulation of Simple Systems

The objective of Homework 1 is for students to understand and apply randomness in simulation using spreadsheet models.

For submission, kindly submit your work for all questions in 1 PDF file and 1 Excel file.

Exercise 1: Simulation of a Single-Channel Queuing System

Given a drink store with only one checkout counter. The distributions of time between arrival and service time are given in *Table 1* and *2*, respectively.
- Complete *Table 1* and 2.
- Given *Table 3* and *4* that display the determination of time between arrivals and service time, *Table 3* and *4*.
- Describe the system process via a flowchart.
- Analyze the system by simulating arrival and service of 25 customers in *Table 5*. Explain your steps in detail.
- Compute the following indicators of the system's performance and explain your calculation in detail:
    - Average waiting time
    - Probability of wait
    - Probability of idle server
    - Average service time
    - Average time between arrivals
    - Average waiting time of those who wait
    - Average time customer spends in the system
- What are your comments and suggestions to improve the system?

Table 1

Distribution of time between arrivals			
Time between arrivals (minutes)	Probability	Cumulative probability	Random digit assignment
1	0.038		
2	0.065		
3	0.163		
4	0.081		
5	0.081		
6	0.131		
7	0.065		

8	0.098		
9	0.147		
10	0.131		

Table 2

Distribution of service time			
Service time (minutes)	Probability	Cumulative probability	Random digit assignment
1	0.241		
2	0.305		
3	0.206		
4	0.145		
5	0.103		

Table 3

Determination of time between arrivals		
Customer	Random digits	Time between arrivals (minutes)
1	-	
2	577	
3	110	
4	146	
5	920	
6	610	
7	211	
8	830	
9	412	
10	219	
11	283	
12	365	
13	108	
14	506	
15	156	
16	253	
17	222	
18	349	
19	866	
20	340	
21	570	

22	806	
23	630	
24	268	
25	233	

Table 4

Determination of service time		
Customer	Random digits	Service time (minutes)
1	273	
2	276	
3	893	
4	323	
5	549	
6	384	
7	751	
8	100	
9	818	
10	751	
11	150	
12	855	
13	246	
14	696	
15	948	
16	728	
17	577	
18	390	
19	123	
20	948	
21	444	
22	689	
23	590	
24	778	
25	162	

Table 5

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)
				Simulation table				
1	-	0						
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

Exercise 2: Simulation of a Two-Server Queuing System

Consider a two-server queuing system, the distributions of time between arrival and service time are given. Similarly,

- Describe the system process via a flowchart.
- Analyze the system by simulating the arrival and service of 25 customers in table.
- Complete all the tables and explain your steps in detail.
- What are your comments and suggestions to improve the system?

Distribution of time between arrivals			
Time between arrivals (minutes)	Probability	Cumulative probability	Random digit assignment
2	0.38		
3	0.27		
4	0.15		
5	0.14		
6	0.06		

Time-service distribution of server 1			
Service time (minutes)	Probability	Cumulative probability	Random digit assignment
3	0.18		
4	0.21		
5	0.28		
6	0.19		
7	0.14		

Time-service distribution of server 2			
Service time (minutes)	Probability	Cumulative probability	Random digit assignment
4	0.21		
5	0.34		
6	0.27		
7	0.18		

Simulation table for a two-server queuing system					Sever 1			Server 2			
Customer	Random digit for arrival	Time between arrivals	Clock time of arrival	Random digit for service	Time service begins	Service time	Time service ends	Time service begins	Service time	Time service ends	Time in queue
1	-	-	0	18							
2	75			31							
3	55			78							

4	83			3								
5	79			36								
6	57			51								
7	74			89								
8	99			97								
9	24			52								
10	30			46								
11	54			86								
12	25			19								
13	27			57								
14	34			23								
15	89			41								
16	27			31								
17	99			95								
18	16			55								
19	95			84								
20	22			36								
21	14			26								
22	9			71								
23	41			4								
24	53			56								
25	10			69								