**Department of Statistics & Operations Research**

**College of Science**

**King Saud University**

**OR 441**

**Final Examination**

**Second Semester 1442**

**Question 1**

Use the following random numbers U(0, 1) shown in the table and the direct transformation method to generate random numbers that follow the normal distribution with μ=20, σ=3.

Write and attach the detail solutions then fill the following table.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| R1 | R2 | Z1 | Z2 | X1 | X2 |
| 0.2379 | 0.7551 |  |  |  |  |
| 0.2989 | 0.247 |  |  |  |  |

**Question 2**

At a grocery store one counter, customers arrive at random from 1 to 5 minutes apart (each of inter-arrival time has the same probability of occurrence). The service times vary from 1 to 5 minutes with the probabilities 0.1, 0.2, 0.3, 0.25 and 0.15, respectively. Analyze the system by simulating the arrival and service of 5 customers.

Use the following random numbers for simulating the arrival customers:

0.01, 0.913, 0.727, 0.015, 0.648

(hint: Fill the following tables)

A. Create tables for simulating the arrival customers:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time between arrivals (min) | Probability | Cumulative Probability | Intervals for choosing Time between arrivals (min) | |
| From | to |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Customer Number | 1 | 2 | 3 | 4 | 5 |
| Random Number | 0.01 | 0.913 | 0.727 | 0.015 | 0.648 |
| Arrival time (min) |  |  |  |  |  |

**Continue question 2…next page**

B. Use the following random numbers for simulating the service customers:

0.841, 0.102, 0.742, 0.535, 0.176,

Create a table for simulating the service time for the customers:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Service Time (min) | Probability | Cumulative Probability | Intervals for choosing Service Time (min) | |
| From | to |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Customer Number | 1 | 2 | 3 | 4 | 5 |
| Random Number | 0.841 | 0.102 | 0.742 | 0.535 | 0.176 |
| Service time (min) |  |  |  |  |  |

Using the above information, fill the following table

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Customers Number | Time between arrivals (min) | Arrival time (min) | Service time  (min) | Service start (min) | Do customers wait? | Departure time (min) | Wait time | Cashier idle time |
| 1 |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |

**Continue question 2…next page**

Having the data computed in the previous table find the following:

1. The average waiting time for a customer
2. The probability that a customer has to wait in the queue
3. The fraction of idle time of the server
4. The probability of the server being busy
5. The average service time
6. The expected service time
7. The average time between arrivals
8. The expected time between arrivals
9. The average waiting time of those who wait
10. The average time a customer spends in the system

**Question 3**

Using the linear congruential (LCG) method check if the LCG generator has a full period conditions with *X0=1*, *m=26, a= 17, c=19*. Find the first 10 values in the period of the generator with the given values.