v)

Step 1: Set Up the Spreadsheet

**Create Columns:** Open a new Excel spreadsheet and create the following columns:

Customer ID

Interarrival Time

Arrival Time

Service Time

Service Start Time

Service End Time

Waiting Time

Time in System

Idle Time

**Define Parameters:** Set the parameters for interarrival and service times:

Interarrival Times: Uniformly distributed between 1 and 15 minutes.

Service Times: Uniformly distributed between 1 and 8 minutes.

Step 2: Generate Random Values

**Interarrival Time:** In the first row under "Interarrival Time," use the formula:

=RANDBETWEEN(1, 15)

Drag this formula down for 20 customers to generate random interarrival times.

**Arrival Time:** For the first customer, set the arrival time to 0. For subsequent customers, calculate the arrival time by adding the interarrival time to the previous customer's arrival time:

Text

=B2 + C2

(Assuming B2 is the interarrival time of the first customer and C2 is the arrival time of the first customer).

**Service Time:** Use the formula for service time in the corresponding column:

=RANDBETWEEN(1, 8)

Drag this down for all customers.

**Step 3: Calculate Service Start and End Times**

Service Start Time: The service start time for the first customer is equal to their arrival time. For subsequent customers, it is the maximum of their arrival time and the previous customer's service end time:

=MAX(D2, F1)

(Assuming D2 is the arrival time of the current customer and F1 is the service end time of the previous customer).

**Service End Time:** This is calculated by adding the service time to the service start time:

=E2 + G2

Step 4: Calculate Waiting Time, Time in System, and Idle Time

Waiting Time: This is the difference between the service start time and the arrival time:

=E2 - D2

Time in System: This is the total time spent in the system, calculated as the difference between the service end time and the arrival time:

=F2 - D2

Idle Time: For the first customer, it is 0. For subsequent customers, it is the difference between the arrival time and the service end time of the previous customer if the arrival time is greater:

=IF(D2 > F1, D2 - F1, 0)

Step 5: Calculate Performance Measures

Average Customer Time in System (W): Use the AVERAGE function to calculate the average time in the system:

=AVERAGE(H2:H21)

Total Simulation Time: This is the total time of the simulation, which is 180 minutes (3 hours).

Total Idle Time: Sum the idle times:

=SUM(I2:I21)

Proportion of Time the Server is Idle (1 - ρ): Calculate the proportion of idle time:

=Total Idle Time / Total Simulation Time

**Step 6: Replicate the Simulation**

Data Table for Replications: To run 50 replications of the simulation, set up a data table:

Create a new section in the spreadsheet for each replication.

Copy the entire simulation setup and paste it for 50 times.

Use Excel’s Data Table feature to automate this process, linking the random generation functions to the replication index.

**Summary of Results**

After completing the simulation for 20 customers over 3 hours and running 50 replications, you will obtain:

Average Customer Time in System (W): This will indicate how long, on average, customers spend in the checkout process.

Proportion of Time the Server is Idle (1 - ρ): This will show the percentage of time the cashier is not serving customers.

This structured approach allows you to effectively simulate and analyze the checkout process in an e-commerce environment using Excel.