Homework #1

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Question 1.1

Name several entities, attributes, activities, events, and state variables for the following systems

a. A cafeteria. Entities: students, cooks, and teachers. Attributes: Assigned lunch period, the amount of food available Activities: serving a student lunch, or a student eating. Events: the changing of a period, students entering or leaving. state variables: period number, number of students fed.

b. A grocery store. Entities: customers, items of food, and cashiers. Attributes: the amount of food available, the scheduled working hours of the cashiers Activies: Bagging, walkin through the aisles. Events: A customer arriving or leaving State variables: number of busy cashiers, number of customers in store.

c. A laundromat Entites: customers, employees, washing machines Attributes: size of load, whether a washing machine is being used or not, working hours of employees. Activities: running a load Events: washing machine breaking down State variables: number of washing machines busy, number of employees working

d. A fast food restaurant Entities: Customers, employees, items of food Attributes: Whether an employee is busy or not, type of food, working hours of employee, employee assignment (counter, cook, etc) Activities: Cooking, serving customer at counter, serving customer at drive through Events: Customers arriving or leaving State variables: Number of customers, number of employees working

e. A hospital emergency room Entities: Patients, nurses, doctors Attributes: Type of illness, specialty of doctor, working hours of doctors and nurses Activities: Treating a patient, Events: A major accident State variables: capacity of hospital

f. a taxi cab company with 10 taxis Entities: Cabs, drivers, customers Attributes: age of cab, whether the cab is functional or not, working hours of drivers, origin and desired destination of customers, location of cab Activities: Picking up and dropping off customers Events: A cab breaks down, a major event that leads to an influx of passengers State variables: Amount of traffic

g. An automobile assembly line Entities: Scrap metal, assembly robots, workers Attributes: Type of worker, schedule of workers, whether workers or robots are idle. Activities: Performing a specific assembly action Events: Accident, robot breaking down State variables: Automobile demand

Question 2.1

Consider the following continuously operating job shop. Interarrival times of jobs are distributed as follows:

Time Between Arrivals (Hours)	Probability
0	.23
1	.37
2	.28
3	.12

Processing times for jobs are normally distributed, with mean 50 minutes and standard deviation 8 minutes. Construct a simulation table and perform a simulation for 10 new customers. Assume that, when the simulation begins, there is one job being processed (scheduled to be completed in 25 minutes) and there is one job with a 50-minute processing time in the queue.

I repurposed the model for example 2.5 for this question. I added a cumulative probability table and calculated the interarrival times using the DescreteEmp() function. The service time was calculated by rounding a random pull from the normal distribution: INT((8*NORM.S.INV(rnd01()))+50) (multiplying by 8 and adding 50 to account for the mean and standard deviation.)

a. What was the average time in the queue for the 10 new jobs? There was some pretty large variability if we in the average time in the queue. On the last run, it was 23.6 minutes.

b. What was the average processing time of the 10 new jobs? This tracked pretty closely to what was expected by taking random draws from the normal distribution. On the last run, it was 47.3

c. What was the max time in the system for the 10 new jobs? This also varied a lot. On the last run it was 140.

2.2 A baker is trying to figure out how many dozens of bagels to make each day. The probability distribution of the number of bagel customers is as follows:

Number of customers/Day	8	10	12	14
Probability	0.35	0.39	0.25	0.10

Customers order 1, 2, 3, or 4 dozen bagels according to the following probability distribution:

Number of Dozen ordered/Customer	1	2	3	4
Probability	0.40	0.30	0.20	0.10

Bagels sell for $8.40 a dozen. They cost $5.80 per dozen to make. All bagels not sold at the end of the day are sold at half-price to a local grocery store. Based on 5 days of simulation, how many dozen (to the nearest 5 dozen) bagels should be baked each day?

To solve this problem, I repurposed the News Dealer's inventory spreadsheet. I changed the simulation table over several days into a table that represents a maximum of 14 customers in a single day. Elsewhere in the spreadsheet, in a single cell I simulated the number of customers per day, based on the probability distribution given. In the table, when calculating the number of dozens of bagels ordered per customer, I added a condition that the number would be 0 if the customer number was higher than the number of customers simulated. So, if in one simulation 8 customers visited the store, customers 9 - 14 in my table would be recorded as buying 0 bagels.

Here are five simulations of the number of bagels ordered in a day:

24 dozen bagels ordered by 10 customers 27 dozen bagels ordered by 10 customers 29 dozen bagels ordered by 14 customers 24 dozen bagels ordered by 10 customers 16 dozen bagels ordered by 8 customers

If we simply made sure we had just enough bagels to cover the highest demand out of those five days, I'd make sure to order 29 dozen bagels (or 30 to the nearest 5 dozen bagels.)

Question 2.4

Smalltown Taxi operates one vehicle during th 9AM to 5PM period. Currently, consideration is being given given to the addition of a second vehicle to the fleet. The demand for taxis follows the distribution shown:

Time between calls (minutes)	15	20	25	30	35
Probability	0.14	0.22	0.43	0.17	0.04

The distribution of time to complete a service is as follows:

Time between calls (minutes)	5	15	25	35	45
Probability	0.12	0.35	0.43	0.06	0.04

Simulate 5 individual days of operation of the current system and of the system with an additional taxicab. Compare the two systems with respect to the waiting times of the customers and any other measures that might shed light on the simulation.

For the one cab model, I reworked the model for example 2.5 again. I set my clock to end after a ride went past the 5pm mark (measured in the spreadsheet as 480 minutes.) This means that if a fare had an arrival time of 475, and a service time of 20 minutes, it would be the last fare picked up. This technically means that if the arrival time is 475, and there's an additional wait time, the fare could get picked up after 5. I decided to allow for this discrepancy.

In this model, there are customer waiting times. Running it for 5 days, I came up with total wait times of 150, 180, 150, 980 (I thought that was an outlier but I just got unlucky with a lot of long trips and short interarrival times), and 515. There is definitely reason to believe a second car could be useful.

However, the second car would be idle a lot of the time. I reworked the Able Baker model to work with this problem. I kept Able as the preferred car if it was free. I counted the service time of Baker and then subtracted that from 480 to arrive at a total idle time for Baker. I ended up with idle times of 450, 455, 365, 345, and 410 for five days of the two car model.

The tradeoff here is how ok would we be with a second car that was idle for most of the day. If we were to assume that riders begin dropping off if they wait for too long, perhaps it would make sense to add the second car.

Question 2.5

The random variables X, Y, and Z are distributed as follows:

$$X\ N(\mu = 100, \sigma^2 = 100)$$
$$Y\ N(\mu = 300, \sigma^2 = 225)$$
$$Z\ N(\mu = 40, \sigma^2 = 64)$$

Simulate 50 values of the random variable

$$W = \frac{X + Y}{Z}$$

In excel, I just made a table of X, Y, and Z variables, with a fourth column for W. X, Y, and Z were calculated using the norm.s.inv function. Replacing μ and σ with their corresponding values (and remembering to take the square root since variances are given above), I used the following formula:

=SQRT(σ)*NORM.S.INV(Rnd01())+μ

Then, I just calculated the W by using the formula = (X+Y)/Z. I ended up with the simulations below:

W 8.2884247 16.94655604 12.36579572 9.578001532 6.989934107 13.96786759 7.033430237 8.886158048 13.8390031 10.28289005 7.987229714 16.17614015 12.11863781 11.14601059 18.16229883 9.180866836 8.370016254 7.725171716 11.36177736 12.76458948 15.58167554 12.88750968 9.445737912 13.56930612 7.524518619 6.985443007 18.51212832 9.33824899 9.073823932 12.52946257 10.80781433 7.874063171 8.375214669 16.45790843 11.5822118 9.826088161 8.478389587 7.739786437 10.53228732 7.492508598 12.04667919 7.98375268 11.57104189 9.935343409 15.28439018 8.236602651 10.43705925 9.256274833 10.65783864 9.328601194

Chapter 2, Question 7

Estimate, by simulation, the average number of lost sales per week for an inventory system that functions as follows:

a. Whenever the inventory level falls to or below 10 units, an order is placed. Only one order can be outstanding at a time. Here, I assumed that this meant the review period would be 1 day. On whatever day the inventory drops below 10, an order is placed. I changed the conditions in the refriginventory sheet to change the pending order only if the previous day's "days until order arrives" was 0. This stopped overlapping orders (without this, the orders would be placed every day, and there would be negative orders as a result to get back to the maximum inventory.) Running this 5 times, I get shortage values of 3, 4, 2, 1, and 7.

b. The size of each order is equal to 20-I, where I is the inventory level when the order is placed. Here I assumed the review period was set back to 5 days. I changed the max inventory to 20, and changed the pending order column formula so that it didn't add the shortage, and the order would simply be 20 - I. Running this 5 times, I get shortage values of 1, 12, 5, 0, and 0.

c. If a demand occurs during a period when the inventory level is zero, the sale is lost. Before, I was counting the number of shortages to attempt to quantify potential lost sales. Here, we're given a particular condition: sales are lost if the inventory level is zero and there is demand. To calculate this, I added another column that tested if the inventory level was zero and there was positive demand, and added the demand as the number of lost sales. In running the simulation 5 times, I ended up with lost sales values of 4, 4, 6, 0, 0.

d. Daily demand is normally distributed, with a mean of 5 units and a standard deviation of 1.5 units (round off demands to the closest integer during the simulation and, if a negative value results, give it a demand of 0.) For this question, I started with the original refrig workbook. It's unclear if we should be "building" on our previous answers To run this simulation, I used the formula =IF(INT(1.5$times$NORM.S.INV(rnd01())+5)>=0, INT(1.5$times$NORM.S.INV(rnd01())+5),0) to set the normally distributed demand. Using the rules of lost sales in part c (as well as shortage), after 5 simulations I ended up with total shortages of 230, 232, 169, 226, 173.

e. Lead time is distributed uniformly between zero and 5 days, integers only. Here I changed the Lead time formula to =IF(D19=L6,discreteuniform(0,5),0). I ended up with shortages of 217, 137, 79, 261, and 11.

f. The simulation will start with 18 units in inventory. This question made me think the simulations were building off of eachother... The default max number of units was originally 11. I set this to 20 in the original spreadsheet. I ended up with total shortages of 0 for several simulations.

g. For simplicity, assume that orders are placed at the close of the business day and received after the lead time has occurrred. Thus, if lead time is one day, the order is available for distribution on the morning of the second day of business following the placement of the order. This should just be all of the simulations… I don't believe anything would need to be changed in order to run this simulation.

h. Let the simulation run for five weeks. For this I just lengthened the simulation table. I ended up with shortages of 21, 12, 3, 18, 1

Chapter 2, Question 8

An elevator in a manufacturing plan carries exactly 400 kg of material. There are three kinds of material packaged in boxes that arrive for a ride on the elevator. these materials and their distributions of time between arrivales are as follows:

It takes the elevator 1 min to o up to the second floor, 2 minutes to unload, and 1 minute to return to the first floor. The elevator does not leave the first floor unless it has a full load. Simulate 1 hour of operation of the system. What is the average transit time for a box of material A (time from its arrival until it is unloaded)? What is the average waiting time for a box of material B? How many boxes of material C make the trip in 1 hour?