COIS 4470H - Winter 2023

Assignment 2

Due: Tuesday, Feb. 28th, 2023

1. **Inventory system:** An automobile dealership uses a weekly periodic inventory review policy. Assume the maximum space for cars is S=80 and the minimum inventory level is s=20. Operation costs are assumed as:

- Holding cost (C_holding) - $25 per car per week
- Shortage cost (C_Shortage) - $700 per car per week
- Set up cost (C_SetUp) - $1000 per order
- Unit cost (C_Unit) - $8000 each car ordered

(a) Modify the programs **sis1.c** or the **sis1.java** to compute all four components of the total average cost per week. Use the input file sis1.dat. (sis1.c, sis1.java and sis1.dat can be found in the source code folder).

(b) Use your program to compute and complete the following table (S=80):

s	0	5	10	15	20	25	30	35	40
Average holding cost/week									
Average shortage cost/week									
Average setup cost /week									
Sum of the three costs/week									

(c) What could be the optimum value for *s*? Explain.

(d) Re-do (a)-(c) with the following assumptions that backorder is not permitted and set up cost depends on the number of items ordered (no change on other cost):

$$C\_SetUp = \begin{cases} 1000 \text{ if order } \leq 70 \\ 1200 \text{ if order } > 70 \end{cases}$$

(e) Modify your program in (d) to output the number of customers who were not satisfied (left without getting a car) every week.

(f) Re-do (a)-(c) with the assumption that customers who were not satisfies will come again in the following week (additional demand for the following week).

2. Three dice are rolled and the largest of the three up faces is recorded. Let X be this value, the possible values of X are 1, 2, …, 6. Use Monte Carlo simulation to estimate the probability of each possible value. Do the experiment for 1000 times and record the results in the following table.

if largest=1: count1+=1
else if
..
else

The largest number X	1	2	3	4	5	6
Estimated Probability						

Note: The function that returns a random number (uniform distribution) between 0 and 1:

```
double rand_val(void)
{
    double z;   // Random value to be generated and returned
    // Use rand() and RAND_MAX defined in stdlib()
   z = (double) rand() / RAND_MAX;
   return(z);
}
```

```
import random
n = 1000
int count1, count2, count3, count4, count5, count6 ALL= 0
int largest;
for i in range (1, n+1):
  largest=(random.randint(1,6), random.randint(1,6), random.randint(1,6))
```

3. Monte-Carlo simulation

#angle theta
q = np.random.uniform(-np.pi, np.pi, numValues)

r = int(input("Enter radius: "))#ask user for radius input
a #alpha
b #beta
np.stack(a,b)
numValues = 1000

(a) Develop a Monte-Carlo simulation program that generates uniformly distributed points on the circumference of a circle (Fig. (a)). The center of the circle (α, β) and radius ρ should be inputs from the users at run time. You can assume that the parameters are in a reasonable range. (Hint: consider the following formula).

$$\theta = \text{uniform}(-\pi, \pi); \quad x = \alpha + \rho * \cos(\theta); \quad y = \beta + \rho * \sin(\theta);$$

(b) Now we want the program to generate uniformly distributed points *inside* a circle with center (α, β) and radius ρ. (Fig. (b)).

x < a + r *cos(q);
y < b + r *sin(q);

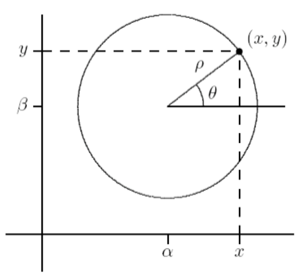

Fig. (a)

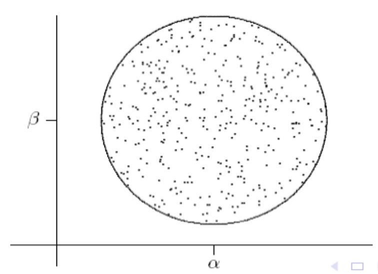

Fig. (b)

Test each of the following two algorithms and determine if they are correct. Show sample output of your program. Discuss the results.

Algorithm 1:

$$\theta = \text{Uniform}(-\pi, \pi); \quad r = \text{Uniform}(0, \rho);$$
$$x = \alpha + r*\cos(\theta); \quad y = \beta + r*\sin(\theta);$$

Algorithm 2:

```
do {
        x = Uniform(-ρ, ρ);
        y = Uniform(-ρ, ρ);
    } while (x * x + y * y >= ρ * ρ);
        x =  α+ x;
        y = β + y;
        return (x, y);
```

*interarrival time
GENERATE 15, 10.5

*service time
ADVANCE 14,5

4. Patients arrive at a doctor's office every 15±10.5 minutes. It takes the doctor 14±5 minutes to serve a patient. Simulate the above system in GPSS for 100 customers.

START 100
END 0

(a) What are the average delay time (from patients arrive until they start to receive service), average number of patients in the waiting room and the doctor's idle time.

Mean waiting time	Mean number of patients In the waiting room	Maximum number of patients in the waiting room	Doctor's idle time

(b) What would happen to the above system if patients arrive every 5±3.5 minutes?

Mean waiting time	Mean number of patients in the waiting room	Maximum number of patients in the waiting room	Doctor's idle time

(c) What would happen to the above system if patients arrive every 20±3.5 minutes?

Mean waiting time	Mean number of patients in the waiting room	Maximum number of patients in the waiting room	Doctor's idle time

(d) What would be the results if the interarrival time and service time are exponentially distributed with mean 15minutes and 14 minutes respectively?

Mean waiting time	Mean number of patients in the waiting room	Maximum number of patients in the waiting room	Doctor's idle time

(e) In model (d), how many patients waited less than 10 minutes, more than 10 but less than 15, more than 15 but less than 20, more than 20 minutes before receiving service from the doctor?

Less than 10 minutes	Between 10 and 15 minutes	Between 15 and 20 minutes	More than 20

5. You have been hired as a consultant by Minute Lube who advertise that they can do a filter, lube and oil in 15 minutes total (no appointment necessary) or its free. Their service has proved so popular that they are unable to meet this restriction and as a result they are giving away too many free services. Upon your examination of the garage, you notice that it consists of three hoists (where a car must first be put on a hoist to do the filter, lube and oil) and three mechanics. The garage is open 5 days a week, 8 am to 6 pm. You also observe that on average, a mechanic can do a filter, lube and oil in 10 minutes and cars arrive at an average of 15 per hour.

(a) You first decide to model this system by assuming that both the interarrival and service times are uniformly distributed. The interarrival times are average$\pm$1 and service times are average$\pm$2.

i) Simulate this model for 2000 customers and give the average time a car spends at the garage, the utilization of the mechanics (i.e., hoists), and the percentage of time a customer has to wait over 15 minutes.

ii) Instead of using 2000 customers, rerun this simulation (producing the same performance measures) using a time period corresponding to 6 working weeks. How many customers went through the system in this period?

(b) You determine that your results from your model in Part (a) are flawed because the interarrival and service times are not uniformly distributed but exponentially distributed with means 4 and 10 respectively.

i) Redo part (a) (i) assuming exponential distribution.

ii) What does the mean service time have to be in order to that less than 20% customers have to spend more than 15 minutes at the garage (use 0.5 minute granularity).

(c) In order to improve the efficiency, you propose to re-organize the service department by having one of the mechanics spend all of his time driving cars on and off the three hoists while the other two to do the actual filter, lube and oil jobs. Assume that it takes on average 1 minute to put a car on a hoist, 2 minutes to take the car off the hoist and 7 minutes to do the actual service (all exponentially distributed). Hint: set up your program so that you first obtain a hoist and then obtain the hoist and then obtain the mechanic to put the hoist.

i) Simulate the above system for 2000 customers and give the average time a car spends at the garage, the utilization of the hoists, driver and mechanics, and the percentage of time a customer has to wait over 15 minutes. Comment on your results.
ii) Assume that you came into money and hire 1 more mechanic (for a total of 3 working on cars and 1 driving cars onto an off the hoists) and install 2 more hoists (for a total of 5 hoists). What happens to the results in Part i). Comments on your results.

Guidelines for submission:

Give all your answers and discussions in a pdf file named: yourLastName-A2. Submit both the answer file and all programs on Blackboard by 11:59pm on the due date.