# **COIS 4470H Modelling and Simulation Assignment 2 Punyaja Mishra**

## **Question 1 – Inventory System**

Language : Python

C\_HOLDING = $25/week  
C\_SHORTAGE = $700/week  
C\_SETUP = $1000/week  
C\_UNIT = $8000/week

### **Part a and b**

S = 80

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **s** | **0** | **5** | **10** | **15** | **20** | **25** | **30** | **35** | **40** |
| **Average Holding Cost/week** | 854.5 | 917.5 | 917.5 | 955.75 | 1060.0 | 1144.5 | 1208.0 | 1262.25 | 1277.5 |
| **Average Shortage Cost/Week** | 797.99 | 371.0 | 371.0 | 343.0 | 175.0 | 14.0 | 0.0 | 0.0 | 0.0 |
| **Average Setup Cost/Week** | 320.0 | 340.0 | 340.0 | 350.0 | 390.0 | 440.0 | 470.0 | 500.0 | 510.0 |
| **Sum of Three Costs/Week** | 1972.49 | 1628.5 | 1628.5 | 1648.75 | 1625.0 | 1598.5 | 1678.0 | 1762.25 | 1787.5 |

### **Part c – Optimal Number of ‘s’**

Optimal Value for s = 25

Ideally, when the business has the LEAST cost, that is the optimal number, which is s=25. The higher the s is, the higher the holding cost, even though shortage cost is 0.00. Similarly, the lower it is, the higher the shortage cost, heavier orders.

### **Part d and e– NO Backorder and different Set up Costs based on Number of Orders + unsatisfied customers**

Text

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|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **s** | **0** | **5** | **10** | **15** | **20** | **25** | **30** | **35** | **40** |
| **Average Holding Cost/week** | 23.75 | 854.25 | 854.25 | 902.5 | 1020.0 | 1130.0 | 1197.5 | 1256.75 | 1272.5 |
| **Average Shortage Cost/Week** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Average Setup Cost/Week** | 10.0 | 406.0 | 406.0 | 410.0 | 434.0 | 472.0 | 490.0 | 506.0 | 514.0 |
| **Sum of Three Costs/Week** | 33.75 | 1260.25 | 1260.25 | 1312.5 | 1454.0 | 1602.0 | 1687.5 | 1762.75 | 1786.5 |
| **Unsatisfied Customers** | 2849 | 266 | 266 | 248 | 143 | 20 | 6 | 2 | 4 |

**Optimal Number s = 30**

The number of unhappy customers are low while also the total cost is low.

### **Part f – additional demand**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **s** | **0** | **5** | **10** | **15** | **20** | **25** | **30** | **35** | **40** |
| **Average Holding Cost/week** | 23.75 | 700 | 805 | 810.25 | 1003.75 | 1117.5 | 1181 | 1250.5 | 1215.5 |
| **Average Shortage Cost/Week** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Average Setup Cost/Week** | 10.0 | 574 | 562 | 566 | 520 | 508 | 520 | 506 | 530 |
| **Sum of Three Costs/Week** | 33.75 | 1274 | 1367 | 1376.25 | 1523.75 | 1625.5 | 1701 | 1756.5 | 1745.5 |
| **Unsatisfied Customers** | 13956 | 1069 | 628 | 684 | 128 | 25 | 4 | 2 | 4 |

**Optimal Number s = 30**

The number of unhappy customers are low while also the total cost is low.

## **Question 2: 3 Die Experiment Monte Carlo Simulation**

Language = Python

Text, letter

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|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Largest of 3 Numbers X | 1 | 2 | 3 | 4 | 5 | 6 |
| Estimated Probability | 0.01 | 0.03 | 0.1 | 0.16 | 0.29 | 0.41 |

## **Question 3 : Monte- Carlo Simulation**

Language : Python

Testing the 2 algorithms for Center = (1,1) and Radius = 2

Text

Description automatically generated

**Algorithm 1 :**

**Text, letter

Description automatically generated**

This is correct for Part a. This gives us all the points ON the circle. I sed matplotlib.pyplot to print the results as a visualization. Please see below.

Shape, circle

Description automatically generated

**Algorithm 2:**

Text, letter

Description automatically generated

This algorithm is not correct because it generates all points that liw OUTSIDE of circle. To correct this, e change the while condition from “>=” to “<=” since we want it to lie within the circle.

Here is the output before correction:

A picture containing chart

Description automatically generated

After correction :

Chart, bubble chart

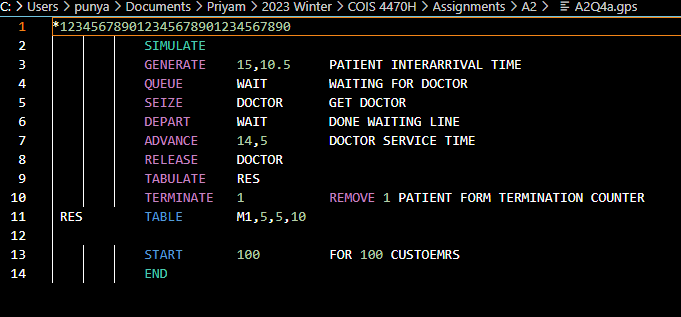
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## **Question 4 – GPSS Program 1**

GPSS Program calculates the Average Delay time for Patient from when they arrive till when they get service.

1. **Interarrival Time = 15 +- 10.5 minutes  
   Service Time = 14 +- 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  (1 – AVG Total Time) |
| 0.00 | 0.00 | 1 | 0.075 |



1. **Interarrival Time = 5 +- 3.5 minutes  
   Service Time = 14 +- 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 |
| 188.026 | 37.286 | 75 | 0.008 |

A screenshot of a computer

Description automatically generated with medium confidence

1. **Interarrival Time = 20 +- 3.5 minutes  
   Service Time = 14 +- 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 |
| 0.00 | 0.00 | 1 | 0.305 |

A screenshot of a computer

Description automatically generated with medium confidence

1. **Interarrival Time = RVEXP(1, 15) minutes  
   Service Time = RVEXP(1, 14) minutes**

|  |  |  |  |
| --- | --- | --- | --- |
| Mean Waiting Time | Mean Number of Patients in the waiting Room | Maximum Number of Patients in the Waiting Room | Doctor’s Idle Time |
| 89.549 | 5.850 | 20 | 0.107 |

Text

Description automatically generated

1. **Interarrival Time = RVEXPO(2, 15) minutes   
   Service Time = RVEXPO(3, 14) minutes**

|  |  |  |  |
| --- | --- | --- | --- |
| Less than 10 minutes | Between 10 and 15 minutes | Between 15 and 20 minutes | More than 20 |
| 4 | 1 | 3 | 92 |

A screenshot of a computer

Description automatically generated with medium confidence

## **Question 5 – GPSS Program 2**

3 hoists – 3 servers – 3 mechanics

Interarrival time = avg 15 cars per hour = 4 minutes for each car

Service time = avg 10 minutes

1. **Interarrival times = 4 +-1  
   service time = 10 +- 2**

**Customers = 2000**

1. First Model – 2000 customers

|  |  |  |
| --- | --- | --- |
| Avg time car spends at garage | Utilization of mechanic | Percentage of time customer waits > 15 minutes |
| 2.518 | Total Time = 0.833  Avg time = 10.10  Avg Contents = 2.499 | 1 |

Text

Description automatically generated

1. Second Model, based on time period  
   Total Time = 10 hours a day \* 5 days a week \* 6 weeks \* 60 minutes = 18000

**Number of customers that went through the system = 4493**

Text

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1. **Interarrival times = RVEXPO(2, 4)  
   service time = RVEXPO(3, 10)**

**Customers = 2000**

1. First Model – RVEXPO

|  |  |  |
| --- | --- | --- |
| Avg time car spends at garage | Utilization of mechanic | Percentage of time customer waits > 15 minutes |
| 17.800 | Total Time = 0.779  Avg time = 9.732  Avg Contents = 2.338  Contents Waited = 21  Avg Wait Time = 8.083 | 953 |

1. 20% of 2000 customers = 400  
   Less than 400 customers spend more than 15 minutes in the system

**Average Service Time = 7.5 minutes**

For Service time exponentially distributed with mean 7.5 minutes, the number of customers that spend more than 15 minutes = 387 < 400

For Service time exponentially distributed with mean 7 minutes, the number of customers that spend more than 15 minutes = 316 < 400

For Service time exponentially distributed with mean 8 minutes, the number of customers that spend more than 15 minutes = 455 > 400



1. **Interarrival times = RVEXPO(2, 4)  
   Hoist up Time = RVEXPO(1,1)  
   Service time = RVEXPO(3, 7)**

**Hoist Down Time = RVEXPO(2,2)**

**Customers = 2000**

1. First Model ~~2000~~ 400 customers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Avg time car spends at garage | Utilization of Hoists (3) | Utilization of Driver (1) | Utilization of mechanic (2) | Percentage of time customer waits > 15 minutes |
| 90.446 | Total Time = 0.965 Avg Time = 13.240  Avg Content = 2.984 | Total Time = 0.672 Avg Time = 1.541  Avg Content = 0.672 | Total Time = 0.757 Avg Time = 6.925  Avg Content = 1.514 | 368 |

Text

Description automatically generated

1. Mechanics = 3; Hoists = 5; Driver = 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Avg time car spends at garage | Utilization of Driver (1) | Utilization of Hoists (3) | Utilization of mechanic (2) | Percentage of time customer waits > 15 minutes |
| 20.057 | Total Time = 0.748 Avg Time = 1.541  Avg Content = 0.748 | Total Time = 0.749 Avg Time = 15.310  Avg Content = 3.743 | Total Time = 0.562 Avg Time = 6.931  Avg Content = 1.686 | 263 |

Text

Description automatically generated with medium confidence

Observations:

* The average time a car spends at the garage decreases drastically. The number of customers spending more than 15 minutes also decreases.