TUTORIAL 1: Single server queue

- A small grocery store has only checkout counter. Customers arrive at this checkout counter at random from 1 to 8 minutes apart. Each possible value of service time has the same probability of occurrences as shown in table. Analyze the system and tabulate output statistics of 20 customers.

Service time in minutes	Probability
1	0.10
2	0.20
3	0.30
4	0.25
5	0.10
6	0.05

- Consider a drive-in restaurant where carhops take orders and bring food to the car. Cars arrive in the manner shown in table. There are two carhops-Able and Baker. The service distribution table for Able and Baker is shown below. Simulate table for carhop.

Time between arrivals(minutes)	Probability
1	0.25
2	0.40
3	0.20
4	0.15

Service Distribution of Baker	
Service time in minutes	Probability
3	0.35
4	0.25
5	0.20
6	0.20

Service Distribution of Able	
Service time in minutes	Probability
2	0.30
3	0.28
4	0.25
5	0.17

TUTORIAL 2: Inventory

- A classical inventory problem concerns the purchase and sale of newspapers. The paper seller buys the papers for 33 cents each and sells them for 50 cents each. Newspapers not sold at the end of the day are sold as scrap for 5 cents each. Newspapers can be purchased in bundles of 10. Thus the paper seller can buy 50, 60, and so on. There are three types of newsdays, “good”, “fair”, and “poor”, with probabilities of 0.35, 0.45, and 0.20, respectively. The distribution of papers demanded on each of these days is given in table. The problem is to determine the optimal number of papers the newspaper seller should purchase. This will be accomplished by simulating demands for 20 days and recording profits from sales each day. The different probabilities for Good, Fair and Poor type of newsday are 0.35, 0.45 and 0.20. Find the profit Distribution of Newspapers Demanded

Demand Probability Distribution			
Demand	Good	Fair	Poor
40	0.03	0.10	0.44
50	0.05	0.18	0.22
60	0.15	0.40	0.16
70	0.20	0.20	0.12
80	0.35	0.08	0.06
90	0.15	0.04	0.00
100	0.07	0.00	0.00

- Suppose that the maximum inventory level, M, is 11 units and the review period, N, is 5 days. The problem is to estimate, by simulation, the average ending units in inventory and the number of days when a shortage condition occurs. The distribution of the number of units demanded per day is shown in table. In this problem, lead time is a random as shown in table. Assume that orders are placed at the close of business and are received for inventory at the beginning of business as determined by the lead time. Tabulate the simulation results. The simulation has been started with the inventory level at 3 units and an order of 8 units scheduled to arrive in 2 day’s time.

Lead time(Days)	Probability
1	0.6
2	0.3
3	0.1

Demand	Probability
0	0.10
1	0.25
2	0.35
3	0.21
4	0.09

- A firm sells bulk rolls of newsprint. The daily demand is given in the table shown. The leadtime is number of days from placing an order until the firm receives the order from the supplier. In this instance, lead time is a random variable is given in the table. Calculate the lead time demand for above problem.

Daily Demand (Rolls)	Probability
3	0.20
4	0.35
5	0.30
6	0.15

Lead time (Days)	Probability
1	0.36
2	0.42
3	0.22

- A baker is trying to determine how many dozens of bagels to bake each day. The probability distribution of the number of bagel customer is shown in table. Customers order 1, 2, 3, or 4 dozen bagels according to the below distribution table.

No. of customers/day	Probability
8	0.35
10	0.30
12	0.25
14	0.10

No. of Dozen ordered/customer	Probability
1	0.4
2	0.3
3	0.2
4	0.1

Bagels sell for $5.40 per dozen. They cost $3.80 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 simulation, how many dozen (to the nearest 10 dozen) bagels should be baked each day.

o A plumbing supply firm is interested in the distribution of led time demand of industrial sinks. The probability distribution for daily demand is known and occurs as shown in table. The distribution of lead time has been reconstructed from past records as shown in table.

Daily Demand (Rolls)	Probability
0	0.18
1	0.39
2	0.29
3	0.09
4	0.05

Lead time (days)	Probability
0	0.135
1	0.223
2	0.288
3	0.213
4	0.118
5	0.023

Develop the distribution of lead-time demand based on 20 cycles of lead-time. Prepare a histogram of the distribution using intervals 0-2, 3-5,… Then, prepare a histogram using intervals 0-1, 2-3, 4-5,… Does changing the width of the interval have a pronounced effect on the form of the histogram of the lead-time demand distribution?

TUTORIAL 3: Reliability Problem

- A large milling machine has three different bearings that fail in service. The cumulative distribution function of the life of each bearing is identical as shown in table. When a bearing fails, the mill stops, a repairperson is called, and a new bearing is installed. The delay time of the repairpersons arriving at the milling machine is also a random variable, with the distribution given as delay time in minutes for 5, 10 and 15 with probability of 0.6, 0.3 and 0.1 respectively. Downtime for the mill is estimated at $5 per minute. The direct on-site cost of the repairperson is $15 per hour. It takes 20 minutes to change one bearing, 30 minutes to change two bearings, and 40 minutes to change three bearings. The bearing costs $16 each. A proposal has been made to replace all three bearings whenever a bearing fails. Management needs an evaluation of this proposal. Simulate for 20,000 hours.

Bearing Life (Hours)	Probability
1000	0.10
1100	0.13
1200	0.25
1300	0.13
1400	0.09
1500	0.12
1600	0.02
1700	0.06
1800	0.05
1900	0.05

Delay time in minutes	Probability
5	0.6
10	0.3
15	0.1

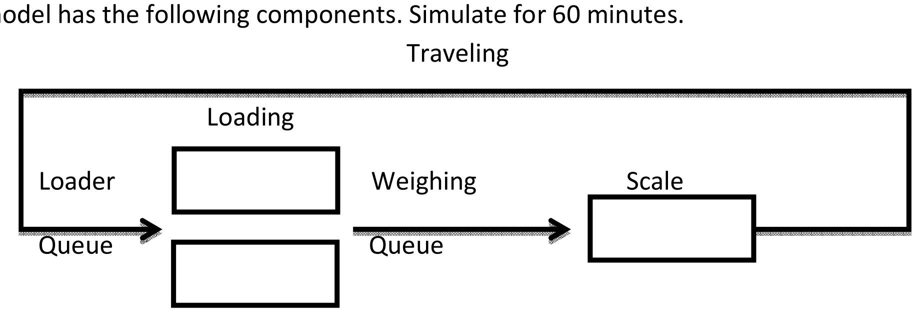
TUTORIAL 4: Multi –server Queue

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

1. Smalltown Taxi operates one vehicle during the 9:00 A.M. to 5:00 P.M. period. Currently, consideration is being given to the addition of a second vehicle to the fleet. The demand for taxis follows the distribution shown. The distribution of time to complete a service is shown in table. Simulate five individual days of operation of the current system and 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 situation

Daily Demand (Rolls)	Probability
0	0.18
1	0.39
2	0.29
3	0.09
4	0.05

- Six dump trucks are used to haul coal from the entrance of a small mine to the railroad. The figure provides a schematic of the dump truck operation. Each truck is loaded by one of two loaders. After loading, a truck immediately moves to the scale, to be weighed as soon as possible. Both the loaders and the scale have a first-come, first-served waiting line (orqueue) for trucks. Travel time from a loader to the scale is considered negligible. After being weighed, a truck begins a travel time (during which time the truck unloads) and then afterwards returns to the loader queue. The distributions of loading time, weighing time, and travel time are given in tables, together with random digit assignment for generating these variables using random digits from a table. The purpose of the simulation is to estimate the loader and scale utilizations (percentage of time busy). The model has the following components. Simulate for 60 minutes.



Loading time	Probability
5	0.30
10	0.50
15	0.20

Weighing time	Probability
12	0.70
16	0.30

Travel time	Probability
40	0.40
60	0.30
80	0.20
100	0.10

TUTORIAL 5: Multi-variate & time series

Records pertaining to the monthly number of job-related injuries at an underground coal mine were being studied by a federal agency. The values for the past 100 months were as follows.

Injuries per month	Frequency of Occurrence
0	35
1	40
2	13
3	6
4	4
5	1
6	1

a) Apply the chi-square test to these data to test the hypothesis that the underlying distribution is Poisson. Use a level of significance of $\alpha= 0.05$.

b) Apply the chi-square test to these data to test the hypothesis that the distribution is Poisson with mean 1.0. Again let $\alpha = 0.05$.

c) What are the differences in parts a) and b), and when might each case arise.

- The numbers of patrons staying at a small hotel on 20 successive nights were observed to be 20, 14, 21, 19, 14, 18, 21, 25, 27, 26, 22, 18, 13, 18, 18, 18, 25, 23, 20, and 21. Fit both an AR(1) and an EAR(1) model to this data. Decide which model provides a better fit by looking at a histogram of this data.