DEPARTMENT OF MECHANICAL ENGINEERING
BM7002-OPERATIONS RESEARCH
QUESTION BANK
UNIT 1 – Linear Models
PART – A (2 Marks)

1. Define Operations Research?
2. What is linear programming?
3. What are slack and surplus variables?
4. Find the dual of the following LPP.
Max $Z=x_1+2x_2+x_3$
Subject to $2x_1+x_2-x_3 \leq 2$
$-2x_1+x_2-5x_3 \geq -6$
$4x_1+x_2+x_3 \leq 6$
$X_1, x_2, x_3 \geq 0$
5. List out the methods used to obtain initial basic feasible solution in Transportation Problem.
6. Define an assignment Problem.
7. What are the phases of an operations research study?
8. Define Duality in LPP.
9. Define Decision variable.
10. What is the difference between feasible solution and basic feasible solution?
11. What do you mean by standard form of LPP?
12. What do you mean by canonical form of LPP?
13. . What do you mean by degeneracy in a Transportation Problem?
14. State the difference between the Transportation Problem and Assignment.Problem.
15. What is Two phase method?
16. What do you mean by an unbalanced Transportation Problem?
17. With an example, describe how to convert the minimization problem into maximization problem in Simplex method?
18. What are the applications of O.R?
19. What is optimality test in transportation problem?
20. Define Artificial Variable.

Part-B (6 Marks)

1.Minimize $Z=3x_1+2x_2$ solve by graphically.
Subject to $5x_1+x_2 \geq 10$
$x_1+x_2 \geq 6$
$x_1+4x_2 \geq 12$
$X_1,x_2, \geq 0$

2. Write the steps involved in solving LPP Using Graphical method? And also write the applications of Operations Research.

3. A Manufacturer produces two types of models M1 and M2. Each model of the type M1 requires 4 hours of grinding and 2 hours of polishing, whereas each model of the type M2 requires 2 hours of grinding and 5 hours of polishing. The manufacturer has 2 grinders and 3 polishers. Each grinder works 40 hours a week and each polisher works for 60 hours a week. Profit on M1 model is Rs. 3.00 and on model M2 is Rs.4.00. whatever is produced in a week is sold in the market. How should the manufacturer allocate his production capacity to the two types of models, so that he may make the maximum profit in a week? Write a suitable LPP for the above question.

4. A company produces 2 types of hats. Every hat A require twice as much labour time as the second hat be. If the company produces only hat B then it can produce a total of 500 hats a day. The market limits daily sales of the hat A and hat B to 150 and 250 hats. The profits on hat A and B are Rs.8 and Rs.5 respectively. Solve graphically to get the optimal solution.

5. Use Graphical method to solve the following LP problem
Maximize $Z= 15x_1+10x_2$
Subject to the constraints: $4x_1+6x_2 \leq 360$
$3x_1+0x_2 \leq 180$
$0x_1+5x_2 \leq 200$;
$x_1, x_2 \geq 0$

6. Explain the scope of OR.

7. List the phases of OR and explain them.

8. A company manufactures two products A and B. Each unit of B takes twice as long to produce as one unit of A and if the company were to produce only A it would have time to produce 2000 units per day. The availability of the raw material is sufficient to produce 1500 units per day of both a and B combined. Product B recurring a special Ingredient only 600units can be made per day. If A fetches a profit of Rs.2 per unit and B a profit of Rs.4 per unit, Formulate the optimum product min.

9. Write down the mathematical formulation for transportation problem.

10. Use simplex method to solve the following LP problem
Maximize $Z= x_1+x_2+3x_3$
Subject to $3x_1+2x_2+x_3 \leq 3$
$2x_1+x_2+2x_3 \leq 2$
$x_1, x_2 \geq 0$

11. Explain MODI method?

12.a)Obtain the dual of the following primal problem
Minimize $z=3x_1-2x_2+ x_3$
Subject to : $2x_1-3x_2+ x_3 \leq 5$
$4x_1-2x_2 \geq 9$
$-8x_1+4x_2+3x_3=8$
$x_1,x_2 \geq 0$, x_3 is unrestricted.

b) And also write difference between Primal and Dual in LPP.

13. Write down the steps involved in solving Assignment problem using Hungarian Method.

14. A person requires at least 10 and 12 units of chemicals A and B respectively, for his garden. A liquid product contains 5 and 2 units of A and B respectively per bottle. A dry product contains 1 and 4 units of A and B respectively per box. The liquid products are sold for Rs. 30 per bottle, dry products are sold for Rs. 40 per box. How many of each should be purchased in order to minimize the cost and meet the requirements? Formulate the L.P.P.

15. a) Difference between Transportation and Assignment Problem
    b) Difference between Optimal solution and feasible solution

Part-C (10 Marks)

1. Solve by using simplex method,

Maximize Z= Max Z=$4x_1+10x_2$
Subject to $2x_1+x_2\leq10$
$2x_1+5x_2\leq20$
$2x_1+3x_2\leq18$
$X_1,x_2\geq0$

2. A paper mill produces 2 grades of paper namely x and y. Because of raw material restrictions, it cannot produce more than 400 tonnes of grade x and 300 tonnes of grade y in a week. There are 160 production hours in a week. It requires 0.2 hours and 1.4 hours to produce a tone of product x and y respectively, with corresponding profits of Rs.200 and Rs.500 per ton. Formulate the above LPP to maximize the profit using the graphical method.

3. Solve by Using VAM Method

Origin/Destination	D1	D2	D3	D4	Supply
O1	11	13	17	14	250
O2	16	18	14	10	300
O3	21	24	13	10	400
Demand	200	225	275	250	950

4. The Processing time in hours for the jobs when allocated to different machines is indicated below. Assign the machines for the jobs so that the total processing time is minimum?

Machines

		M1	M2	M3	M4	M5
	J1	9	22	58	11	19
	J2	43	78	72	50	63
Jobs	J3	41	28	91	37	45
	J4	74	42	27	49	39
	J5	36	11	57	22	25

5. Solve using Vogel's Approximation Method and perform optimality Test using MODI method

	D1	D2	D3	D4	Supply
O1	2	3	11	7	6
O2	1	0	6	1	1
O3	5	8	15	9	10
Demand	7	5	3	2	17

6.Use penalty method or Big M method to solve Linear Programming Problem
Minimize Z=$4x_1+x_2$
Subject to $3x_1+x_2=3$
$4x_1+3x_2\geq6$
$x_1+2x_2\leq3$
$X_1,x_2\geq0$

PART – A (2 Marks)

1. Define Critical Path?
2. Define Critical Activity?
3. What is dummy activity?
4. What is network scheduling?
5. What is a network?
5. What is spanning tree?
6. What are the three types of float?
7. What is slack?
8. What is float?
9. What is merge event?
10. What is PERT method?
11. What is shortest route problem?
12. Define the expected variance of project length.
13. What is total float?
14. What are the common errors in construction of a network?
15. Define Maximum flow?
16. Define minimum spanning tree?
17. What is the difference between an event and an activity?
18. What are the three phases of project?
19. Difference between preceding and succeeding activity.
20. What is Time Analysis in a network model?

Part-B (6 Marks)

1. a) Distinguish between PERT and CPM,
   b) Distinguish between Free float and Independent Float.
2. Explain the shortest route problem with an example
3. Write short notes on maximum flow models.
4. Explain the minimum spanning tree with an example.
5. Write the steps involved in forward pass and backward pass calculation.
6. Write down the steps used in solving Network Model using Fulkerson's Rule.
7. Listed in the table are the activities and sequencing requirements necessary for completing the research project. Find the critical path.

Activity	A	B	C	D	E	F	G	H	I	J	K	L	M
Duration	4	2	1	12	14	2	3	2	4	3	4	2	2
Immediate Predecessor	E	A	B	K	-	E	F	F	F	I,L	C,G,H	D	I,L

8. Explain in detail about various phases of project management.

9. Calculate the earliest start, earliest finish, latest start and latest finish of each activity of the project given below:

Activity	1-2	1-3	1-5	2-3	2-4	3-4	3-5	3-6	4-6	5-6
Duration (weeks)	8	7	12	4	10	3	5	10	7	4

10. Write short notes on Prim's Algorithm in solving Minimum spanning tree with an example.

11. A project schedule has the following characteristics. Draw the network diagram and find the critical path.

Activity	1-2	1-3	2-4	3-4	3-5	4-5	4-6	5-6
Time(days)	6	5	10	3	4	6	2	9

12. A project schedule has the following characteristics. Draw the network diagram and find the critical path.

Activity	1-2	1-3	2-3	2-4	3-4	4-5
Time(days)	20	25	10	12	6	10

13. Write notes on augmenting path algorithm.

14. A small project consists of seven activities for which the relevant data are given below:

Activity	Preceding Activity	Duration(in days)
A	-	4
B	A	7
C	-	6
D	C	5
E	B	7
F	D,E	6
G	F	5

Draw the network and find the project completion time.

15. Explain the steps in PERT method and also write the formula in calculating project variance and estimated time.

Part-C (10 Marks)
1. The following table shows the jobs of a network along with their time estimates.

Job	1-2	1-6	2-3	2-4	3-5	4-5	6-7	5-8	7-8
a(days)	1	2	2	2	7	5	5	3	8
m(days)	7	5	14	5	10	5	8	3	17
b(days)	13	14	26	8	19	17	29	9	32

Draw the project network and find the probability of project completion in 40 days

2. A project schedule has the following characteristics.

Activity	1-2	1-3	2-4	3-4	3-5	4-9	5-6	5-7	6-8	7-8	8-10	9-10
Time(days)	4	1	1	1	6	5	4	8	1	2	5	7

From the above information, you are required to
1. Construct a network diagram.

2. Compute the earliest and latest event time
3. Determine the critical path and total project duration.
4. Compute the total and free float for each activity.

3. A project has the following activities and other characteristics:

Estimated Duration (in weeks)			
Activity(i-j)	Optimistic	Most likely	Pessimistic
1-2	1	1	7
1-3	1	4	7
1-4	2	2	8
2-5	1	1	1
3-5	2	5	14
4-6	2	5	8
5-6	3	6	15

(i) What is the expected project length? (ii) What is the probability that the project will be completed no more than 4 weeks later than expected time?

4. A small maintenance project consists of the following jobs whose precedence relationships are given below.

Job	1-2	1-3	2-3	2-5	3-4	3-6	4-5	4-6	5-6	6-7
Duration (days)	15	15	3	5	8	12	1	14	3	14

  (i) Draw an arrow diagram representing the project (ii) Find the total float for each activity (iii) Find the critical path and the total project duration.

5. Explain Kruskal's Algorithm to solve Minimum spanning tree with an example.

6. The Stagecoach Shipping Company transports oranges by six trucks from Los Angeles to six cities in the West and Midwest. The different routes between Los Angeles and the destination cities and the length of time, in hours, required by a truck to travel each route are shown in figure. Find the shortest travel time to each this destination.
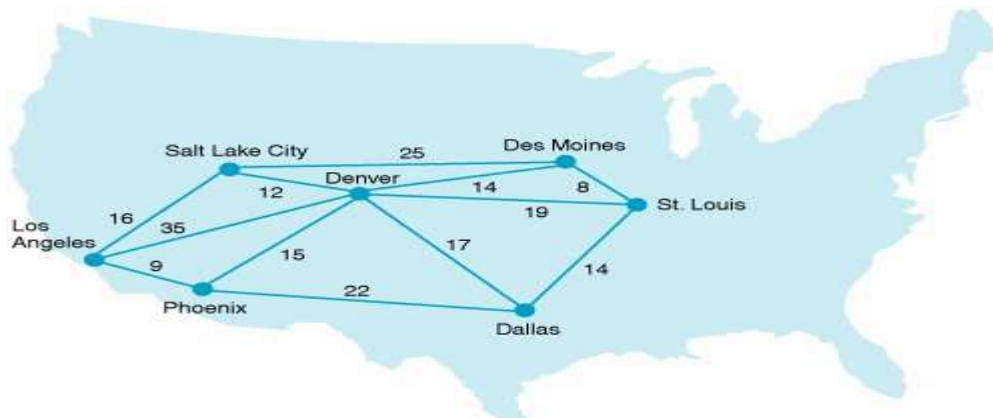
DEPARTMENT OF MECHANICAL ENGINEERING
BM7002-OPERATIONS RESEARCH
QUESTION BANK
UNIT 3 – Inventory Models
PART – A (2 Marks)

1. What is meant by inventory?
2. Mention the various types of inventory.
3. What are the different costs that are involved in the inventory problem?
4. Define holding cost and setup cost
5. Briefly explain probabilistic inventory model.
6. Distinguish between deterministic model and probabilistic model.
7. Define buffer stock or safety stock.
8. Define Lead time and reorder point.
9. Summarize the causes of poor inventory control.
10. Define shortage cost.
11. What is Economic order quantity?
12. Write the EOQ formula under purchasing model with shortages and without shortages.
13. Write the EOQ formula under manufacturing model with shortages and without shortages.
14. Write the formula for finding total cost with price breaks.
15. What is demand?
16. What are controlled variables in inventory problem?
17. What are uncontrolled variables in inventory problem?
18. What is order cycle? On what basis order cycle is created?
19. Write the four types of deterministic inventory models.
20. What is lot size inventory?

Part-B (6 Marks)

1. The demand for an item is 18000 units per year. The holding cost is Rs1.20 per unit time and the cost of shortage is Rs.5.00. The production cost is Rs.400.00. Assuming that replacement rate is instantaneous determine the optimum order quantity.

2. The demand for an item is 12000 per year and the shortage is allowed. If the unit cost is Rs.15 and the holding cost is Rs.20 per year per unit determine the optimum total yearly cost. The cost of placing one order is Rs.6000 and the cost of one shortage is Rs.100 per year.

3. Discuss briefly about the different types of inventory and various costs involved in inventory problems.

4. A company has a demand of 12,000 units/year for an item and it can produce 2000 such items per month. The cost of one setup is Rs.400 and the holding cost/unit/month is Rs. 0.15. Find the optimum lot size and max inventory.

5. A newspaper boy buys papers for 30 paise each and sells them for 70 paise. He cannot return unsold news papers. Daily demand has the following distribution.

No. of customers	23	24	25	26	27	28	29	30	31	32
Probability	0.01	0.03	0.06	0.10	0.20	0.25	0.15	0.10	0.05	0.05

If each day's demand is independent of the previous day's, how many papers should he order each day?

6. The demand of an item is uniform , at a rate of 25 unit per month. The fixed cost is Rs.15 each time a production run is made. The production cost is Rs.1 per item and the inventory carrying cost is Rs.0.30 per item per month. If the shortage cost is Rs.1.50 per item per month, determine the frequency and size of the production run that is to be made.

7. The annual consumption of an item is 2000 units. The ordering cost is Rs.100 per order. The carrying cost is Rs.0.80 per unit, per year. Assuming working days as 200, lead time as 20 days, and safety stock as 100 units, calculate i) EOQ, ii) The number of orders per year.

8. For a fixed order quantity, determine i)EOQ, ii) Optimum buffer stock.
Annual consumption, R=10,000 units, cost of one unit = Rs.1, C_3= Rs.12 per production run, C_1=0.24 per unit. Maximum lead time =30 days and normal lead time =15 days.

9.A particular item has an annual demand of 9000 units. The carrying cost is Rs.2 per unit, per year. The ordering cost is Rs.90. Find i)EOQ ii) Determine the number of orders to be placed per annum.

10. Calculate EOQ and buffer stock from the following data. Annual consumption is 12000 units at the cost of Rs.7.50 per unit. Set up cost is Rs.6 and the average inventory holding cost is Rs.0.12 per unit. Normal lead time is 15 days and maximum lead time is 20 days.

11. Find the optimum order quantity for a product, the price break for which is as follows.

Quantity	Unit cost(Rs.)
$0 \leq q_1 \leq 500$	10
$500 \leq q_2$	9.25

The monthly demand for the product is 200 units, the cost of storage is 2 percent of the unit cost and the cost of ordering is Rs.350.

12.The annual demand for the product is 10,000 units, Each unit costs Rs.100 for orders placed in quantities below 200 units but for orders of 200 or above the price is Rs.95. The annual inventory holding cost is 10 percent of the value of the item and the ordering cost is Rs.5 per order. Find the economic lot size. The cost of storage is 2 percent of the unit cost and the cost of ordering is Rs.500 per order. Find the economic lot size?

13. An item is produced at the rate of 50 units per day. The demand occurs at the rate of 25 items per day. If the set up cost is Rs.100 per run and the holding cost is Rs.0.01 per unit of item, per day, find the economic lot size for one run, assuming that shortages are not permitted. Also find the time of the cycle and minimum cost for one run.

14. Discuss the assumptions made in purchase model with shortages and without shortages and also write the formula involved in their calculations.

15. Discuss the assumptions made in manufacturing model with shortages and without shortages and also write the formula involved in their calculations.

Part-C (10 Marks)

1. A manufacturer has to supply his customer with 600 units of his products per year. Shortages are not allowed and storage cost amounts to 60 paise per unit per year. The set up cost is Rs 80.00 find i) EOQ ii) The minimum average yearly cost. iii) The optimum number of orders per year. iv) The optimum period of supply per optimum order.

2. The following table gives the annual demand and unit price of four items.

Item	A	B	C	D
Annual demand(Units)	800	400	392	13800
Unit Price(Rs.)	0.02	1.00	8.00	0.20

Order cost is Rs.5 per order and holding cost is 10 percent of the price.
i) Determine the EOQ in units.
ii)Calculate total variable cost.
Iii)Calculate the EOQ in year of supply
iv)Determine the number of orders per year?

3. The annual requirement for a product is 3000 units. The ordering cost is Rs. 100 per order. The cost per unit is Rs.10. The carrying cost per unit , per year is 30 percent of the unit cost. i)Find the EOQ. By using better organizational methods, the ordering cost per order can be brought down to Rs. 80 per order, but the same quantity as determined above ha to be ordered. Ii) If a new EOQ I found by using the ordering cost as Rs. 80, what would be the further saving in cost?

4.Find the optimum order quantity for a product or which the price breaks are as follows.

Quantity	Unit Cost(Rs.)
$0 \leq q_1 \leq 100$	Rs.20 per unit
$100 \leq q_2 \leq 200$	Rs.18 per unit
$200 \leq q_3$	Rs.16 per unit

The monthly demand for the product is 400 units. The storage cost is 20% of the unit cost of the product and the cost of ordering is Rs.25.

5.The demand for an item is deterministic and constant over tme and is equal to 600 units per year. The per unit cost is Rs.50, while the cost of placing an order is Rs.5. The inventory carrying cost is 20 percent of the cost of inventory per annum and the cost of shortage is Rs.1 per unit, per month. Find the optimal quantity when stock outs are permitted. If stock outs are not permitted, what would be the loss to the company?

6.Find the optimum order quantity for a product, the price breaks of which are as follows.

Quantity	Unit cost(Rs.)
$0 \leq q_1 \leq 800$	Rs.1
$800 \leq q_2$	Rs.0.98

The yearly demand for the product is 1,600 units, cost of placing an order is Rs.5 and the cost of storage is 10 percent per year.

DEPARTMENT OF MECHANICAL ENGINEERING

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QUESTION BANK
UNIT 4– Replacement Models

PART – A (2 Marks)

1. What is replacement?

2. When should the replacement be done?

3. What are the categories into which the replacements of items are classified?

4. When do we replace a machine considering the time t as a discrete variable and ignoring changes in the value of money?

5. Describe briefly some of the replacement policies?

6. Define group replacement.

7. Define individual replacement.

8. Differentiate between individual and group replacement.

9. Define discount factor.

10. Write is salvage value?

11. Write the formula for optimum replacement when salvage is considered.

12. Write the formula for optimum replacement when salvage value is negligible whose money value changes with time.

13. What is present worth factor?

14. State the conditions under which group replacement is superior to individual replacement.

15. Define Sequencing.

16. Define processing order and processing time.

17. What is the principle assumption made in sequencing problems?

18. When can we apply Johnson's algorithm in finding the optimal ordering of n jobs through 3 machines?

19. Find the present worth factor of the money to be spent in a year, if the money is worth 5 percent per year.

20. Write the expression for weighted average cost.

Part-B(6Marks)

1. A machine owner finds from his past records that the costs per year of maintaining a machine, whose purchase price is Rs.6000, are as given below.

Yr.	1	2	3	4	5	6	7	8
Maintenance cost	1000	1200	1400	1800	2300	2800	3400	4000
Resale price	3000	1500	750	375	200	200	200	200

Determine at what age a replacement is due.

2. The cost of a new machine is Rs. 5000. The maintenance cost of the nth year is given by $C_n=500(n-1)$, n=1, 2…..
Suppose money is worth 5 percent per year, after how many years will it be economical to replace the machine?

3. A machine owner finds from his past records that the costs per year of maintaining a machine, whose purchase price is Rs.8000, are as given below.

Yr.	1	2	3	4	5	6	7	8
Maintenance cost	1000	1300	1700	2200	2900	3800	4800	6000
Resale price	4000	2000	1200	600	500	400	400	400

Determine the time at which it is profitable to replace the truck.

4. The cost pattern for two machines A and B, when money value is not considered, is given in the table below.

Year	Cost at the beginning of year	
	Machine A	Machine B
1	900	1400
2	600	100
3	700	700

Find the cost pattern for each machine when money is worth 10 percent per year and hence, find which machine is less costly.

5. Explain the replacement of items that deteriorate with time under the value of money doesn't change with time and change with time.

6. The following mortality rates have been observed for a certain type of light bulbs.

Week	1	2	3	4	5
Percent failing by the end of week	10	25	50	80	100

There are 1000 bulbs in use and it costs Rs.2 to replace an individual bulb, which has burnt out. If all the bulbs were replaced simultaneously, it would cost 50 paise per bulb. Find the average cost of group replacement policy.

7. The following table gives the running costs per year and resale price of certain equipment, whose purchase price is Rs.5000.

Year	1	2	3	4	5	6	7	8
Running cost	1500	1600	1800	2100	2500	2900	3400	4400
Resale value	3500	2500	1700	1200	800	500	500	500

In what year is the replacement due?

8. The following table gives the running costs per year and resale price of certain machine, whose purchase price is Rs.50,000.

Year	1	2	3	4	5	6	7	8
Running cost (in 1000)	15	16	18	21	25	29	43	40
Resale value (in 1000)	35	25	17	12	8	5	5	5

In what year is the replacement due?

9. The cost of a machine is Rs. 61,000 and its scrap value is Rs.1000. The maintenance costs found from the past experiences are as follows.

Year	1	2	3	4	5	6	7	8
Maintenance cost in Rs.	1000	2500	4000	6000	9000	12000	16000	20000

When should the machine be replaced?

10. There are five jobs, each of which must go through the two machines A and B in the order AB. Processing times are given below.

Job	1	2	3	4	5
Machine A	5	1	9	3	10
Machine B	2	6	7	8	4

Determine a sequence for the five jobs that will minimize the total elapsed time.

11. A company has six jobs, A to F. All the jobs have to go through two machines M1 and M2. The time required for the jobs on each machine in hours is given below. Find the optimum sequence that minimizes the total elapsed time.

Job	A	B	C	D	E	F
M/c1	1	4	6	3	5	2
M/c2	3	6	8	8	1	5

12. The failure rates of 1000 street bulbs in a colony are summarized in table.

End of month	1	2	3	4	5	6
Probability of failure to date	0.05	0.20	0.40	0.65	0.85	1.00

The cost of replacing an individual bulb is Rs. 60. If all the bulbs are replaced simultaneously it would cost Rs. 25 per bulb. Any one of the following two options can be followed to replace the bulbs. Replace the bulbs individually when they fail (individual replacement policy).

13. A truck is priced at Rs.60,000 and running costs are estimated at Rs. 6000 for each of the first four years, increasing by Rs.2000 per year in the fifth and subsequent years. If the money is worth 10 percent per year, when the truck should be replaced. Assume that the truck will eventually be sold for scrap at a negligible price.

14. There are 1000 bulbs in the system. Survival rate is given below.

Week	1	2	3	4	5
Percent failing by the end of week	10	20	40	60	100

Find the optimal costs under individual replacement policy if the cost of replacement is Rs.5 per bulb.

15. There are 500 bulbs in the system. Survival rate is given below.

Week	1	2	3	4	5
Percent failing by the end of week	5	25	50	75	100

Find the optimal costs under group replacement policy if the cost of replacement is Rs.5 per bulb. If all the bulbs were replaced simultaneously it could cost Rs. 2 per bulb.

Part-C (10 Marks)

1. A manufacturer is offered two machines A and B. A is priced at Rs.50,000 and running costs are estimated at Rs.8000 for each of the first five years, increasing by 2000 per year in the sixth and subsequent years. Machine B of the same capacity costs Rs. Rs.25,000 but will have running costs of Rs.12000 per year for six years increasing by Rs.2000 per year thereafter. If money is worth 10% per year, which machine should be purchased?

2. The data on the running costs per year and the resale price of an equipment A whose purchase price is Rs.2 lakhs are as follows. i)What is the average period of replacement. ii) When A is 2years old, an equipment B which is a newly available model. The optimum period of replacement is 4 years with average costs of Rs.72, 000. Should A be changed with B?

year	1	2	3	4	5	6	7
Running cost	30,000	38,000	46,000	58,000	72,000	90,000	1,10,000
Resale value	100,000	50,000	25,000	12,000	8,000	8,000	8,000

3. The probability P_n of failure just before age n is shown below. If individual replacement costs Rs.12.50 and group replacement costs Rs.3 per item. Find the optimal replacement policy.

n	1	2	3	4	5
P_n	0.1	0.2	0.25	0.3	0.15

4. A machine costs Rs.6,000. The running cost and the salvage value at the end of the year is given in the table below.

year	1	2	3	4	5	6	7
Running cost	1200	1400	1600	1800	2000	2400	3000
Salvage value	4000	2666	2000	1500	1000	600	600

If the interest rate is 10 percent per year, when should the machine be replaced?

5. Find the sequence that minimizes the total elapsed time(in hours) required to complete the following tasks on two machines.

Task	A	B	C	D	E	F	G	H	I
M/c1	2	5	4	9	6	8	7	5	4
M/c2	6	8	7	4	3	9	3	8	11

6. Four jobs 1,2,3 and 4 are to be processed on each of the five machines A,B,C,D and E in the order ABCDE. Find the total minimum elapsed time if no passing of jobs is permitted. Also find the idle time for each machine.

Machines	Jobs			
	1	2	3	4
A	7	6	5	8
B	5	6	4	3
C	2	4	5	3
D	3	5	6	2
E	9	10	8	6

1. Define a queue
2. What are the basic characteristics of a queuing system?
3. Define transient and steady state.
4. Explain Kendall's notation.
5. Write Little' formula
6. Define the following (1) Balking (2) Reneging (3) Jockeying
7. List the characteristic of a queueing system
8. Explain the queue discipline and its various forms:
9. Difference between Transient and steady states.
10. Classify Queuing models.
11. Define utilization factor.
12. Write Little's formula.
13. Define a customer.
14. What is the distribution for service time and inter arrival time?
15. Define priority in customer's behaviour.
16. What is efficiency of M/M/S model?
17. Write the meaning of (M/M/1):(∞/FCFS).
18. Write the meaning of (M/M/1):(N/FCFS).
19. Write the formula for finding expected waiting line the queue and queue length L_q of model1.
20. Find the traffic intensity for the mean arrival rate of the customer is 30 per day and the service rate of the server is 48 per day.

Part-B (6Marks)

1. Write the steady-state equation for the model (M/M/C):(FIFO/∞/∞).

2. Obtain the expected waiting time of a customer in the queue of the model λ=10/hour, μ=3/hour C=4, what is the probability that a customer has to wait before he gets service?

3. In a public telephone booth the arrivals are on the average 15 per hour. A call on the average takes 3 minutes. If there is just one phone, find (i) the expected number of callers in the booth at any time (ii) the proportion of the time the booth is expected to be idle?

4. A car park contains 5 cars. The arrival of cars is Poisson at a mean rate of 10 per hour. The length of time each car spends in the car park is exponential distribution with mean of 5 hours. How many cars are in the park on the average?

5. A barber shop has two barbers and three chairs for customers. Assume that the customers arrive in Poisson fashion at a rate of 5 per hour and that each barber services customers according to an exponential distribution with mean 15 minutes. Further, if a customer arrives and

there are no empty chairs in the shop, he will leave. What is the expected number of customers in the shop?

6. A T.V mechanic finds that the time spent on his jobs has an exponential distribution with mean 30 minutes, if he repairs sets in the order in which they come in. If the arrival of sets is approximately Poisson with an average rate of 10 per eight day, which is the mechanic's expected idle time each day? How many jobs are ahead of the average set just brought in?

7. At what average rate must a clerk at a super market work, in order to insure a probability of 0.90 that the customers will not have to wait longer than 12 minutes? It is assumed that there is only one counter, to which customers arrive in a Poisson fashion at an average rate of 15 per hour. The length service by the clerk has an exponential distribution.

8. In a super market, the average arrival rate of customers is 10 every 30 minutes, following Poisson process. The average time taken by a cashier to list and calculate the customer's purchase is two and half minutes following exponential distribution. What is the probability that the queue length exceeds six? What is the expected time spent by a customer in the system?

9. In a public telephone booth, the arrivals on an average are 15 per hour. A call on an average takes three minutes. If there is just one phone, find i) the expected number of callers in the booth at any time ii) the proportion of the time, the booth is expected to be idle.

10. A barber shop has space to accommodate only 10 customers. He can serve only one person at a time. If a customer comes to his shop and finds it full, he goes to the next shop. Customers randomly arrive at an average rate $\lambda=10$ per hour and the berbe's service time is negative exponential with an average of $1/\mu = 5$ minutes per customer. Find P_0 and P_n.

11. People arrive at a theatre ticket centre in a Poisson distributed arrival rate of 25 per hour. Serve time is constant at two minutes. Calculate,

   i) The mean number in the waiting line.
   ii)   the mean waiting time.
   iii)   Utilization factor.

12. Assuming for a period of two hours in a day (8-10 am), trains arrive at the yard every 20 minutes, then calculate for this period.
   i)The probability that the yard is empty.
   ii) Average queue length, assuming that the capacity of the yard is 4 trains only.

13. Four counters are being run on the frontier of a country to check the passports and necessary papers of the tourists. The tourists choose any counter at random. If the arrival at the frontier is Poisson at the rate λ and the service time is exponential with parameter $\lambda/2$, what is the steady state average queue at each counter?

14. At a public telephone booth in a post office, arrivals are considered to be Poisson, with an average inter arrival time of 12 minutes. The length of the phone call may be assumed to be distributed exponentially with an average of four minutes. Calculate the following.

i) What is the probability that a fresh arrival will not have to wait for the phone?

ii) What is the average length of the queue that forms from time to time?

15. A two channel waiting line with Poisson arrivals has a mean arrival rate of 50 per hour and exponential service with a mean service rate of 75 per hour for each channel.

i) The probability of an empty system.

ii) The probability that an arrival in the system will have to wait.

Part-C (10 Marks)

1. Customers arrive at a one-window drive-in bank according to Poisson distribution with mean 10 per hour. Service time per customer is exponential with mean five minutes. The space in front of the window including that for the serviced car can accommodate a maximum of three cars. Others can wait outside this space.

i) What is the probability that an arriving customer can drive directly to the space in front of the window?

ii) What is the probability that an arriving customer will have to wait outside the indicated space?

iii) How long is an arriving customer expected to wait before starting service?

2. In a railway marshalling yard, goods trains arrive at a rate of 30 trains per day. Assuming that inter arrival time and service time distribution follows an exponential distribution with an average of 30 minutes, calculate the following.

i) The mean queue size.

ii) The probability that queue size exceeds 10.

iii) If the input of the train increases to an average of 33 per day, what will be the changes in i) and ii)?

3. A super market has two girls ringing up sales at the counters. If the service time for each customer is exponential with mean four minutes and if people arrive in a Poison fashion at the counter, at the rate of 10 per hour, then calculate,

i) the probability of having to wait for service.

ii) the expected percentage of idle time for each girl.

iii) if a customer has to wait, find the expected length of his waiting time.

4. A petrol pump has two pumps. The service time follows the exponential distribution with mean four minutes and cars arrive for service in a Poisson process at the rate of 10 cars per hour. Find the probability that a customer has to wait for service. What proportion of time do the pumps remain idle?

5. On an average, 96 patients per 24 hour day require the service of an emergency clinic. Also, on an average a patient requires 10 minutes of active attention. Assume that the facility can handle only one emergency at a time. Suppose that it costs the clinic Rs. 100 per patient treated, to obtain an average servicing time of 10 minutes and thus, each minute of decrease in this average time would cost Rs.10 per patient treated. How much would have to be budgeted by the clinic to decrease the average size of the queue from 1⅓ patients to 1/2 patients?

6.In a railway marshalling yard, goods train at the rate of 30 trains per day. Assume that the inter arrival time follows an exponential distribution and the service time is also to be assumed as exponential with mean of 36 minutes. Calculate, i) the probability that the yard is empty.

ii) the average queue length, assuming that the line capacity of the yard is nine trains.

iii) And also find the average queue length, if the goods train arrive at the rate of 40 trains per day.