weight 10 pounds. How much each type of raw material should be used for each unit of final product if company wish to minimize cost?   [20]

         Ans: Cost (C) = Rs. 116 when X_1 = 2 units and X_2 = 14 units

23. 2040 Q.No. 8

Solve the following linear programming problem

Maximize Z = Rs. 4A + Rs. 8B + Rs. 6C

Subject to

$6A + 8B + 4C \leq 120$ $4A + 2B + 4C \leq 80$ $A + 6B + 4C \leq 160$ A, B, C ≥ 0 [20]

         Ans: A = 0; b = 20/3; C = 50/3; Max (z) = Rs. 460/3

24. 2039 Q. No. 8

A company makes three products, A, B and C, each of which is produced from three main elements, E_1, E_2 and E_3. The products are packed in 100 kgs. The contribution for a bag of A is Rs. 30, for a bag of b Rs. 50 and or a bag C Rs. 40. Each product utilizes the number of pound. of each elements shown.

Product	Element		
	E_1	E_2	E_3
A	2	0	3
B	3	2	2
C	0	5	4

There are following limits on the amounts of the elements available.

E_1 - 800 kgs.; E_2 - 1,000 kgs.; E_3 - 1,500 kgs.

How will you determine how much of each product should be produced to maximize contribution?   [20]

         Ans: X_1 = 8900/41; X_2 = 5000/41; X_3 = 6200,41; maximum contribution (z) = Rs. 765,000/41

4. DUALITY LINEAR PROGRAMMING

MBS

NUMERICAL QUESTIONS

1. 2070 Q.No. 11

Write the dual of the following problem and obtain the optimal solution of the dual problem by using simplex method.

Minimize C = Rs.$300X_1 + 200X_2 + 400X_3$

Subject to the constraint

$3X_1 + 2X_2 + X_3 \geq 2$

$4X_1 + X_2 + 3X_3 \geq 4$

$2X_1 + 2X_2 + 2X_3 \geq 3$

Where X_1, X_2, $X_3 \geq 0$ non negative condition.   [20]

       Ans: Primal Solution: Min $Z = \frac{1,150}{3}$; $X_1 = \frac{5}{6}$, $X_2 \frac{2}{3}$, X_3 = 0; Dual Solution: Max $Z = \frac{1,150}{3}$; Y_1 = 0,

                                             $Y_2 = \frac{100}{3}$ $Y_3 = \frac{250}{3}$

2. 2069 Q. No. 10

Write the dual of the problem and convert inequality into equality by adding slack of surplus variables.   [10]

Min. Z = $2x_1 + 3x_2 + x_3$

S.t. $4x_1 + 3x_2 + x_3 = 6$

     $x_1 + 2x_2 + 5x_3 = 4$

     x_1, x_2, $x_3 \geq 0$.

    Ans: Max Z = $-6 y_1 + 6y_2 - 4y_3 + 4y_4$; Subject to: $-4y_1 + 4y_2 - y_3 + y_4 + S_1 = 2$; $-3y_1 + 3y_2 - 2y_3 + 2y_4 + S_2$

                           = 3; $-y_1 + y_2 - 5y_3 + 5y_4 + S_3 = 1$; $y_1, y_2, y_3, y_4, S_1, S_2, S_3 \geq 0$

3. 2067 Q.No. 11

Write the dual of the following problem and then solve the dual problem by using simplex method. Finally interpret the primal and dual values from the dual solution.   [20]

Maximize profit Z = Rs. 4,000 P_1 + Rs. 3,200 P_2

Subject to the constraints

Raw material (kg) $20P_1 + 10P_2 \leq 300$

Labour in assembly (man – hours) $2P_1 + 5P_2 \leq 50$.

Labour in finishing (man – hours) $2P_1 + 3P_2 \leq 38$

Where P_1 and P_2 are two different products and $P_1 P_2 \geq 0$.

Ans: Dual solution: Min Z = 64,800; Y_1 = 140; Y_2 = 0; Y_3 = 600; Primal solution: Max Z = 64,800; P_1 = 13; P_2 = 4

4. **2062 Q.No. 7**

Find the optimum solution for the following problem by using simplex.

Minimize the cost = Rs. 300A + Rs. 800B

Subject to:

$A + B = 200$ $A \leq 40$ $B \geq 30$ where A, B ≥ 0

Interpret the value of dual from the final table of the primal problem. [20]

Ans: A = 40; B = 160, Minimum cost = Rs. 1,40,000 dual variable Y_1 = Rs. 800; Y_2 = Rs. 500, and Y_3 = Rs. 0, maximum profit = Rs. 1,40,000

5. **2061 Q.No. 7**

Write the dual of the following problem and solve them dual problem by using simplex method and interpret the result.

Maximize the profit Rs. $16X_1 + 10X_2$

Subject to:

$4X_1 + 2X_2 \leq 24$ $3X_1 + 3X_2 \leq 21$ $2X_1 + 5X_2 \leq 30$ where, $X_1 \geq 0$ and $X_2 \geq 0$ [20]

Ans: Min (c) = Rs. 100, W_1 = 3, W_2 = 4/3

6. **2058 Q.No. 7**

Obtain the dual of the following problem and interpret the result by finding the solution of the dual problem by using simplex method.

Maximize the profit: Rs. $400X_1 + 320X_2$

Subject to: Assembly constraint in hour $40X_1 + 20X_2 \leq 600$

Product cost constraint in rupees $40X_1 + 100X_2 \leq 1000$

Finishing constraint in hour $2X_1 + 3X_2 \leq 38$ where, $X_1 \geq 0$ and $X_2 \geq 0$ [20]

Ans: Min (c) = Rs. 6480, W_1 = 7, W_2 = 0, W_3 = 60

M B A

7. **2053 Q.No. 6**

Write the dual of the given LPP and obtain its solution by using simplex method. From the dual solution also read the solution of primal LP?

Minimize C = Rs. $(60X_1 + 40X_2 + 80X_3)$

Subject to

$3X_1 + 2X_2 + X_3 \geq 2$ $4X_1 + X_2 + 3X_3 \geq 4$

$2X_1 + 2X_2 + 2X_3 \geq 3$ and $X_1, X_2, X_3 \geq 0$

Ans: X_1 = 5/6; X_2 = 2/3; X_3 = 0, Cost (c) = Rs. 230/3

5. TRANSPORTATION

M B S

NUMERICAL QUESTIONS

1. **2070 Q.No. 9**

A national truck rental firm is planning for a heavy demand of rental trucks during the month of June. From the following data on number of trucks to be allocated and the cost involved, find optimum solution to minimize the transportation cost. [10]

Origin (surplus area)	Destination (shortage area)			Supply of trucks
	1	2	3	
1	50	100	100	110
2	200	300	200	160
3	100	200	300	150
Demand of trucks	140	200	80	420

Ans: Rs. 67,000

2. 2070 Old Q.No. 8a

Determine optimum transportation model and find minimum cost of transportation.   [10]

Stores	Ware house			Requirements
	W_1	W_2	W_3	
	(Cost per unit)			
S_1	45	35	30	60
S_2	60	15	25	40
S_3	45	35	45	60
S_4	30	35	55	20
Availability	70	60	90	

Ans: Rs. 5,500

3. 2069 Q. No. 9

Solve the transportation problem.   [10]

Destination / Origin	D_1	D_2	D_3	Available
O_1	30	20	10	800
O_2	5	15	25	500
Required	300	300	400	

Ans: Total minimum transportation cost = Rs. 10,500

4. 2069 (Old) Q. No. 8a

The following table represents the profit per unit of goods. Find optimal transportation schedule so that the profit is maximized.

Demand centres	Supply centres			Requirements
	S_1	S_2	S_3	
D_1	1300	1700	1800	3000
D_2	1100	1400	1800	3000
D_3	1500	1200	1500	4000
D_4	2000	1300	1200	5000
Availability	2000	6000	7000	15000

Ans: Total maximum profit = Rs. 2,44,00,000

5. 2068 Old Q.No. 8 a

Find the optimum transportation schedule to minimize the cost from the following   [10]

Plant	Stores				Available quantity
	S_1	S_2	S_3	S_4	
P_1	90	120	90	60	70
P_2	70	30	70	70	60
P_3	60	50	90	110	90
Required quantity	60	40	60	20	220 / 180

Ans: Total minimum transportation cost = Rs. 11,000

6. 2067 Q.No. 9

Find optimal transportation schedule to minimize the cost from the following unbalanced transportation problem.   [10]

Plant	Stores				Available quantity
	S_1	S_2	S_3	S_4	
W	29	32	29	26	70
X	27	23	27	27	60
Y	26	25	29	31	90
Demand units	60	40	60	20	

Ans: Total min transport cost = Rs. 4,700

7.   2067 Q.No. 8a (Old)

Using transportation problem, determine the maximum profit from the information given below.

Ware house	Factory			Capacity
	Profit in Rupees			
	X	Y	Z	
A	130	170	180	30
B	110	140	180	30
C	150	120	150	40
D	200	130	120	50
Demand	20	60	70	

Ans: Max Total profit = Rs. 24,400

8.   2066 Q.No. 7 b

Determine the optimum solution for the following problem to minimize the transportation cost: 10

	W_1	W_2	W_3	Supply
P_1	3	8	5	5
P_2	5	5	3	8
P_3	7	8	9	7
P_4	4	9	5	14
Requirements	7	9	18	34

Ans: Minimum transportation cost = Rs. 167 and X_{11} = 5 units; X_{22} = 2 units; X_{23} = 6 units; X_{32} = 7 units ; X_{41} = 2 units; X_{43} = 12 units.

9.   2065 Q.No. 9 a

Find the optimum solution that minimized the transportation cost for following data: [10]

	D_1	D_2	D_3	D_4	Supply
O_1	8	8	10	9	15
O_2	8	12	10	10	25
O_3	12	10	11	11	15
Requirements	15	15	15	10	55

Ans: X_{12} = 15; X_{21} = 15; X_{23} =10; X_{32} = 5; X_{34} = 10; Min. cost = Rs. 505

10.   2064 Q.No. 8 a

Find the optimum solution for the problem below that minimizes the total transportation cost.[10]

	D_1	D_2	D_3	D_4	Supply
P_1	2	3	11	7	6
P_2	1	6	6	1	1
P_3	5	8	15	9	10
Requirements	7	5	3	2	17

Ans: Rs. 100

11.   2062 Q.No. 9 (b)

'Nepal Transport' own several trucks used to deliver crushed stones to road projects in the region. The company has received the delivery schedule for next week as follows:

Project	Requirement per week	Plant	Available per week
A	50	W	55
B	75	X	60
C	50	Y	60

The cost matrix for above schedule is given as follows:

Plant	Cost information ('000 Rs.) Project		
	A	B	C
W	4	8	3
X	6	7	9
Y	8	2	5

Find an optimum solution to minimize the transportation cost.   [10]

Ans: Minimum transportation cost = Rs. 6,65,000

12. 2061 Q.No. 8 (a)

Determine the minimum transportation cost from the following matrix.   [10]

| Warehouse | Stores | | | | Supply |
| | P1 | P2 | P3 | P4 | |
	Cost per unit				
W1	45	60	45	30	70
W2	35	15	35	35	60
W3	30	25	45	55	90
Demand	60	40	60	20	220 / 180

Ans: Minimum transportation cost = Rs. 5,500

13. 2060 Q.No. 8 (a)

From the following profit matrix, find the maximum profit by using transportation model.

Plant	Units Available	Project	Units demanded
A	1700	W	1300
B	2500	X	2000
C	1000	Y	1900

Profit in '000 rupees   [10]

From	To Project W	To Project X	To Project Y
Plant A	12	8	5
Plant B	11	15	10
Plant C	2	17	6

Ans: Maximum profit = Rs. 58,600,000

14. 2059 Q.No. 9 (b)

'Nepal Hardware Company' has three plants in Kathmandu, Banepa and Nuwakot and three warehouses at Bhairhawa, Birgunj and Biratnagar. The quantity available at the plants are respectively 60, 70 and 80, where as the demand at the warehouses are 50, 80 and 80 respectively. The unit cost of transportation are observed as follows:

	Bhairahawa	Birgunj	Biratnagar
Kathmandu	2	5	7
Banepa	2	3	4
Nuwakot	5	8	11

Find an optimum allocation that minimizes the transportation cost.   [10]

Ans: Minimum transportation cost = Rs. 1,090

15. 2058 Q.No. 8 (a)

Find the optimal transportation schedule from following with the objective of minimizing the cost.   [10]

Factory	Quantity requirements per day in kg.	Ware house	Quantity available per day in kg.
P	450	X	350
Q	500	Y	400
R	200	Z	400

Cost of transportation per kg is given in the following table.

| From | To factory | | |
	P	Q	R
Warehouse X	10	20	20
Warehouse Y	40	60	40
Warehouse Z	10	16	24

Ans: Minimum transportation cost Rs. 26,900

16. 2055 Q.No. 7 (a)

Find optimal transportation schedule to minimize the cost from the following information.   [10]

Plants	Stores					Capacities
	S_1	S_2	S_3	S_4	S_5	
P_1	7	10	5	4	12	45
P_2	3	2	0	9	1	70
P_3	8	13	11	6	14	125
Order size	10	20	30	80	100	240

Ans: Minimum transportation cost = Rs. 1,415

17. 2053 Q.No. 7 (a)

Suggest an optimal transportation plan with a view to minimize the cost and determine the minimum transportation cost from the following: [10]

Warehouse	Stores (Cost per units in Rs.)				Supply
	S_1	S_2	S_3	S_4	
W_1	9	12	9	6	7
W_2	7	3	7	7	6
W_3	6	5	9	11	9
					22
Demand	6	4	6	2	18

Ans: Minimum transportation cost = Rs. 110

18. 2052 Q.No. 6 (a)

The Rent-a-car Company rents car trailers to individuals making one way moves. Occasionally the company has to redistribute the trailers in order to eliminate a surplus build up in some cities and a shortage in others. The company currently has 4 trailers in A, 3 in B, 6 in C and 1 in D. They would like to shift 5 trailers to E, 3 to F and 6 to G. The following table gives the mileages between the various sources and destinations.

Sources	Destination		
	E	F	G
A	60	50	80
B	30	40	90
C	60	100	100
D	90	70	30

How should company redistribute the trailers so that total mileage travelled is minimized?   [10]

Ans: Minimum mileage = 750

19. 2050 Q.No. 6 (a)

T.C. Mellott trucking company has a contract to more 115 truck loads of sand per week between three sand-washing plants W, X and Y and three destinations, A, B and C. Cost and volume information is given below. **Compute the optimal transportation cost**   [10]

Project	Requirement per week truck loads	Plant	Available per week truck loads
A	45	W	35
B	50	X	40
C	20	Y	40

Cost information:

From	To project A	To project B	To project C
Plant W	Rs. 5	Rs. 10	Rs. 10
Plant X	20	30	20
Plant Y	5	8	12

Ans: Minimum transportation cost = Rs.1,345

20. 2045 Q.No. 6 (a)

A company has three factories from where 2000 cases have to be transported to five warehouses. The demands of the warehouses, the supplies available at the different factories, and the transportation costs per case are given in the following matrix.

Warehouse	Factory			Demand
	1	2	3	
1	0.50	0.65	0.54	320
2	0.48	0.55	0.60	470
3	0.72	0.60	0.58	440
4	0.53	0.51	0.57	350
5	0.45	0.49	0.59	420
Supply	900	500	600	2000

Find the least cost distribution schedule. [10]

Ans: Minimum transportation cost = Rs. 1,020.70

21. 2042 Q.No. 6 (a)

Suggest an optimal transportation plan with a view to minimize costs from the following information: [10]

Destination	Sources			Units Demanded
	F_1	F_2	F_3	
W_1	Rs. 0.90	Rs. 1.00	Rs. 1.30	5
W_2	Rs. 1.00	Rs. 1.40	Rs. 0.80	20
W_3	Rs. 1.30	Rs. 1.00	Rs. 0.80	20
Units available	20	15	10	45

Ans: Minimum transportation cost = Rs. 42.5

22. 2040 Q.No. 9 (a)

Find the optimal transportation schedule on the basis of the following information: [10]

Factory	Stores (Haulage cost in Rs.)				Availability
	S_1	S_2	S_3	S_4	
F_1	9	7	10	8	14
F_2	8	11	9	11	27
F_3	13	10	12	10	14
Requirement	15	19	11	10	55

Ans: Minimum transportation cost = Rs. 468

23. 2039 Q.No. 9 (a)

ABC Company supplies raw materials to three different factories X, Y and Z from its three different warehouses A, B and C. Cost and volume information are given below. Compute the optimal transportation cost. [10]

Factory	Requirement per week truck loads	Warehouse	Available per week truck loads
X	45	A	35
Y	50	B	40
Z	20	C	40

Cost information:

From	To factory X	To factory Y	To factory Z
Warehouse A	Rs. 50	Rs. 100	Rs. 100
Warehouse B	200	300	200
Warehouse C	50	80	120

Ans: Minimum transportation cost = Rs. 13,450

6. ASSIGNMENT PROBLEM

M B S

NUMERICAL QUESTIONS

1.   2070 Old Q.No. 9a

A company has 4 different types of works to be performed in 4 different machines. Each type of work must be done on one and only one machine. Give the optimum assignments so that the cost is minimum.   [10]

Machines	Works			
	W_1	W_2	W_3	W_4
M_1	12	18	44	23
M_2	30	33	25	30
M_3	21	9	24	28
M_4	15	31	21	14

Ans: Rs. 60

2.   2069 (Old) Q. No. 8b

Five different jobs are to be assigned to four different machines so as to minimize the cost. Find the optimal assignment with the corresponding cost.

Jobs	Machines			
	M_1	M_2	M_3	M_4
J_1	90	70	60	20
J_2	60	60	70	60
J_3	50	30	40	40
J_4	40	20	50	90
J_5	20	80	30	60

Ans: Total minimum cost = Rs. 100

3.   2068 Q.No. 9

A project work consists of four major jobs for which an equal number of contractors have submitted tenders. The tender amount quoted (in millions of rupees) are as follows:

Contractors	Jobs			
	P	Q	R	S
W	30	44	50	35
X	36	42	48	32
Y	32	40	52	30
Z	29	46	54	36

Find minimum cost of optimal assignment, when each contractor has to be assigned at least one job.   [10]

Ans: Total min cost = Rs 157

4.   2068 Old Q.No. 8b

Four different transportation companies are assigned to handle three cargo consignments with a view to maximize the profit. Find optimal assignment so that the profit can be maximized.   [10]

Transportation companies	Cargo consignment		
	C_1	C_2	C_3
T_1	50	200	250
T_2	100	150	150
T_3	150	150	150
T_4	250	50	100

Ans: Total max. profit = Rs.650

5. **2067 Q.No. 8b (Old)**

Assign jobs to different machines in order to minimize the cost from the information given below and compute minimum cost.

Machines	Job		
	P	Q	R
A	18	8	10
B	24	13	15
C	28	17	19
D	32	19	22

Ans: Total Min. cost = Rs. 50; A - P; B - Q; C - R; D - S

6. **2066 Q.No. 8 b**

A department has four subordinates and four tasks to be performed. The subordinates differ in efficiency and the tasks differ in their intrinsic difficulty. The estimates of the profit in rupees each man would earn is given in the effectiveness matrix below. How should the tasks be allocated, one to each man, so as to maximize the total earnings?   10

	Tasks			
(Subordinates)	1	2	3	4
1	5	40	20	5
2	25	35	30	25
3	15	25	20	10
4	15	5	30	15

Ans: Task 1= man 3; Task 2= man 1; Task 3= man 4; Task 4= man 2; Total cost = Rs. 110

7. **2063 Q.No. 8 (a)**

From the following find the optimal assignment so that the profit is maximized on the basis of one machine to one job.   [10]

Machines	Profit in 'Rs.' Jobs			
	A	B	C	D
X	1800	2400	2800	3200
Y	800	1300	1700	1900
Z	1000	1500	1900	2200

Ans: Maximum profit = Rs. 6,400

8. **2062 Q.No. 8 (b)**

Four children in s household were assigned three different household chores to be done. The children are motivated to get pocket money for the job. Assign are the jobs to the children in such a way that their pocket money income is maximum.   [10]

Children	Clean the house	Wash clothes	Cook dinner
Ram	1	4	5
Laxman	2	3	3
Bharat	3	3	3
Shatrughan	5	1	2

Ans: Maximum pocket money income = Rs. 13

9. **2059 Q.No. 8 (a)**

The ABC Company has three jobs to be done on three machines. Each job must be done on one and only one machine. The cost of each job on each machine is given in the following table.

Cost information:

Jobs	Machine		
	X	Y	Z
A	4	6	8
B	2	3	4
C	4	8	5

Give the job assignments, which will minimize cost.

Ans: Minimum cost = Rs. 12; X → A, Y→ B, Z→C

MBA

10. 2056 Q.No 5 (a)

Assign the job to machine in the following data of opportunity cost to minimize opportunity cost:

Jobs	Machine		
	M_1	M_2	M_3
A	Rs. 25	Rs. 31	Rs. 35
B	Rs. 15	Rs. 20	Rs. 24
C	Rs. 22	Rs. 19	Rs. 17

Ans: Minimum cost = Rs. 62; A→X, B→Y, C→Z

11. 2054 Q.No. 7 (a)

The innovative product company is considering an expansion into five new sales districts. The company has been able to hire four new experienced sales persons. Upon analysing the new sales person's experience in combination with a personality test which was given to them, the company assigned a rating to each of the salespersons for each of the districts. These ratings are as follows:

Sales Persons	Districts				
	1	2	3	4	5
A	92	90	94	91	83
B	84	88	96	82	81
C	90	90	93	86	93
D	78	94	89	84	88

The company knows that with four sales persons, only four of the five potential districts can be covered. It would like to know which four districts the sales persons should be assigned in order to maximize the total of the ratings. [10]

Ans: Maximum total ratings = Rs. 375

12. 2048 Q.No. 6 (a)

Find the optimal assignment for the given problem, where four person are assigned to four jobs. [10]

Persons	Jobs			
	1	2	3	4
1	3	5	11	4
2	2	1	6	9
3	8	10	2	7
4	10	6	1	5

Ans: Minimum assignment cost = Rs. 11

13. 2046 Q.No. 6 (a)

The advanced company has three jobs to be done on three machines. Each job must be done on one and only one machine. The cost of each job on each machine is given in the following table. [10] Cost information:

Jobs	Machine		
	X	Y	Z
A	Rs. 25	Rs. 31	Rs. 35
B	Rs. 15	Rs. 20	Rs. 24
C	Rs. 22	Rs. 19	Rs. 17

Give the job assignments, which will minimize the cost.

Ans: Minimum cost = Rs. 62; A→X, B→Y, C→Z

14. 2041 Q.No. 6 (a)

The ABC Motor works has four machines on which to do four jobs. Each job can be assigned to only one machine. The cost of each job on each machine is given in the following table. What are the job assignments which will minimize costs? [10]

Machines	Jobs			
	1	2	3	4
W	3	5	11	4
X	2	1	6	9
Y	8	10	2	7
Z	10	6	1	5

Ans: Minimum cost = Rs. 11

7. SIMULATION

N/A

8. QUEUING THEORY

MBS

THEORETICAL QUESTIONS

1. 2070 Old Q.No. 5
What is a queue? Describe various characteristic of queue and queuing system.   [10]

2. 2067 Q.No. 5
What is a queue? Describe various operation characteristics of a queue and queuing system. [10]

3. 2058 Q.No. 6
What is queue? Describe the various operation characteristics of queue and queuing system.[10]

NUMERICAL QUESTIONS

4. 2070 Q.No. 10a
In the post office, customers arrive in the ticket window is 10 per hour. The service rate of the window is 15 customers per hour. Find the probability that (i) the employee in the counter is idle and (ii) customer arriving has to wait for the service.   [5]
Ans: $\frac{1}{3}, \frac{2}{3}$

5. 2069 Q. No. 7b
If the arrival of customers for service is 10 per hour and the average service rate is 12 customers per hour.
  i.   What is the probability that there are 5 customers in the system?
  ii. Find the length of the queue?   [5]
Ans: (i) 0.07 (ii) 4.17 customers

6. 2065 Q.No. 9 b
A person repairing radios finds that the time spent on the radio sets has an exponential distribution with mean 20 minutes. If the radios are required in the order in which they come in and their arrival is approximately Poisson with an average rate of 15 for 8-hour day, what is the repairman's expected idle time each day? How many jobs are ahead of the average set just brought in?   [10]
Ans: 3 hrs; 5/3 ≈ 2 sets

7. 2064 Q.No. 8 b
On the average 96 patients per 24 hours day require the service of an emergency clinic. Also on the average, a patient requires 10 minutes of active attention. Assume that the facility can handle only one emergency at a time. If this situation satisfy all the conditions for apply queuing theory, find the average (expected) queue length and the waiting time for the patient to be served.   [10]
Ans: Queue length = 1.33 and waiting time = 20 minutes

8. 2063 Q.No. 6
What is maintenance management? How can theory of queuing be utilized in maintenance management system? Cars arrive in a store (single channel) at an average rate of six per hour and service rate for the channel is 10 per hour. What is the length of the queue?   [10]
Ans: 0.90

9.   **2061 Q.No. 9 (b) (ii)**

A departmental store has a single cashier. During rush hours, customers arrive at the rate of 20 customers per hour. The average number of customers that can be processed by the cashier is 24 per hour. Assume that thee conditions for use of single-channel queuing model apply. What's the (a) probability that the cahier is idle? (b) average no. of customers in queuing system? (c) average time a cashier spends in the system ? (d) average time a customer spends in the queue waiting for services?   [6]

Ans: (a) $P_0 = 0.17$ (b) 5 customers (c) 15 minutes (d) 12.5 minutes

9. FORECASTING

N/A

10. NETWORKING

M B S

NUMERICAL QUESTIONS

1.   **2070 Q.No. 7**

Draw a network diagram and identify the critical path for the following information: [10]

Activities	A	B	C	D	E	F	G	H	I
Predecessor	–		–	A	B	C	D, E	B	F, H
Expected time (days)	4	8	4	3	3	9	9	6	10

Ans: Critical Path = C–F–I

2.   **2070 Old Q.No. 8b**

Construct PERT diagram for a project with following activities   [10]

Activity	Pre-requisite activities	Completion time in days
A	–	4
B	–	7
C	A	4
D	A	3
E	B	2
F	B	6
G	C, E	5
H	G, F	8

i.   Find the expected completion time of the project and the critical path.
ii.   Slack time of each activity.

Ans: (i) 22 days and B–E–G–H (ii) 1, 0, 1, 15, 0, 1, 0, 0

3.   **2069 Q. No. 11**

Following table shows jobs, activities, their normal and crash time, normal and crash cost estimated for a project:

Job	Activity	Normal		Crash		Variance
		Time (days)	Cost (Rs.)	Time (days)	Cost (Rs.)	
1-2	A	7	1400	5	1800	2
1-3	B	9	2000	6	2800	3
2-3	C	5	1100	3	1500	3
2-4	D	3	800	2	1400	4
3-4	E	4	500	3	750	1
3-5	F	6	900	3	1600	2
4-6	G	10	2500	6	3000	3
5-6	H	3	500	2	800	4

i.   Draw the network of the project.
ii.   Find normal duration and cost of the project.
iii.   What will be the project duration and cost of all the activities are crashed.
iv.   Find the optimum duration and minimum project cost.
v.   What is the probability that the project will be completed 4 days later than expected time?
vi.   Find the optimum duration and minimum projection cost.
vii.   Find project completion time which will have 99% confidence.   [20]

Ans: (ii) 26 days and Rs. 9,700 (iii) 17 days and Rs. 11,516.67 (iv) 17 days and Rs. 11,516.67 (v) 90.82% (vii) 32.99 days

4.   2069 (Old) Q. No. 9a

The following table represents eight activities of a project with different time periods.

Activity	Predecessors activity	Times in weeks		
		Optimistic	Most Likely	Pessimistic
A	None	1	4	7
B	None	5	11	17
C	A	3	3	3
D	A	1	5	7
E	B	8	14	26
F	B	2	5	8
G	C	5	5	5
H	G, F	2	5	8

i.   Draw network diagram and identify the critical activities.
ii.   Find variance of each activity and find the probability that the project will be completed with in 41 days.

Ans: (ii) 99.97%

5.   2068 Q.No. 10

The following is a network diagram of a project consisting 13 activities with their corresponding expected time.
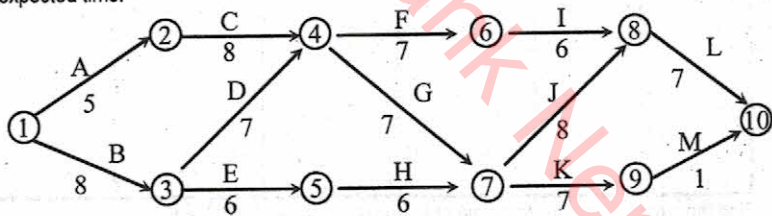
Find (i) Possible paths (ii) Critical path and length of project (iii) Slack time of each activity   [10]
Ans: (i) A – C – F – I – L; A – C – G – J – L; A – C – G – K – M; B – D – F – I – L; B – D – G – J – L; B – D – G – K – L; B – E – H – J – L; B – E – H – K – M (ii) B – D – G – J – L and 37 (iii) A = 2; B = 0; C = 2; D = 0; E = 9; F = 2; G = 0; H = 9; I = 2; J = 0; K = 7; L = 0; M = 7

6.   2068 Old Q.No. 9b

Draw a network diagram for the following 13 activities. Find the critical path and slack time of each activity.   [10]

Activity	Preceeding activity	Estimated time (days)
A	None	12
B	None	10
C	B	4
D	C	4
E	A,D	4
F	D	2
G	A,D	12
H	E	10
I	G,H	12

J	I	4
K	G	8
L	J,K	6
M	L	2

Ans: Max. project length = 56 days; Critical path = B – C – D – d_1 – E – H – I – J – L – M and critical activities are, B, C, D_1, E, H, I, J, L, M. Slack time: A = 6; B = 0; C = 0; D = 0; E = 0; F = 36; G = 2; H = 0; I = 0; J = 0; K = 10; L = 0; M = 0

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7.   2067 Q.No. 10

Draw a network diagram of a project consisting activities.   [10]

Activity	Preceding activity	Time estimates (weeks)		
		Most optimistic	Most pessimistic	Most likely
A	None	2	12	14
B	None	10	26	12
C	A	8	10	9
D	A	10	20	15
E	A	7	11	7.5
F	B,C	9	9	9
G	D	3	7	3.5
H	E,F,G	5	5	5

Find: (1) Critical path and length of project (2) Variance of each activity.

Ans: (1) A – D – G – I and 35 - 67 weeks; (2) 25/9, 64/9, 1/9, 25/9, 4/9, 0, 4/9, 0

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8.   2067 Q.No. 9a (Old)

Using critical path method, draw the diagram of the given project composed of eight activities. Find the minimum completion time of the project by using time-cost trade off concept.

Activity	Pre-requisite activity	(Cost in Rs.)		(Time in weeks)	
		Normal	Crash	Normal	Crash
A	None	20	19	4500	4900
B	None	18	16	4000	4900
C	B	17	16	3000	3500
D	A	16	15	5000	5900
E	C, D	19	17	4800	6400
F	A	20	18	6000	7400
G	B	14	14	1500	1500
H	E, F	17	16	3500	4200

Ans: Total min. time = 67 weeks; Total project cost = Rs. 35,550

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9.   2066 Q.No. 8 a

The time estimates (in weeks) for the following activities are given as below, determine the critical path and the minimum competition time of the project:

Activity	1-2	1-3	1-4	2-5	3-5	4-6	5-6
T_o	1	1	2	1	2	2	3
T_m	3	3	2	2	5	5	6
T_p	9	7	10	3	12	10	12

What is the probability that the project will be completed within scheduled time, if the scheduled time is 20 weeks?   10

Ans: 0.9664

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10.   2065 Q.No. 8 b

The time estimates (in weeks) for the activities of a network are given below:

Activity	1-2	1-3	1-4	2-5	3-5	4-6	5-6
T_o	1	1	2	1	2	2	3
T_m	1	4	2	1	5	5	6
T_p	7	7	8	1	14	8	15

Draw the project network and identify the critical path. Also find out the scheduled completion time for probability of completion to be 99%.   [10]

Ans: Critical Path: 1-3-5-6; Scheduled time= 23.99 ≈ 24 weeks

11. 2064 Q.No. 9 a

Draw a network diagram and determine the critical path for the following utility data and determine the minimum completion time in days.   [10]

Activity	0-1	1-2	1-3	2-4	2-5	3-4	5-6	4-7	5-7	6-7
Duration (days)	2	8	10	6	3	3	7	5	2	8

Ans: 0-1-2-5-6-7 and 28 days

12. 2063 Q.No. 8 (b)

A small project composed of eight activities and their time estimates are as follows:

Activity	Pre-requisite Activity	Time required (days)		
		Optimistic	Most Likely	Pessimistic
A	None	1	4	7
B	None	5	10	17
C	A	3	3	3
D	A	1	4	7
E	B	8	15	26
F	B	2	4	8
G	C, E	5	5	5
H	G, F	2	5	8

i.   Draw a network diagram and find the expected project completion work.
ii.   What is the probability that the project will be completed within 41 days?
iii. What should be the scheduled completion time for the probability of completions to be 95%?   [10]

Ans: (i) Expected project length = 36 days (ii) 90.99% (iii) 42.15 days

13. 2062 Q.No. 8 (a)

Construct the PERT diagram for a project with following activities:

Activity	A	B	C	D	E	F	G	H	I	J
Predecessors	None	None	A, B	B	A	C	E, F	D, F	G, H	I
Days	4	7	4	3	2	1	6	5	8	9

i.   Find ES, Ls and slack time
ii.   Find the expected completion time
iii. Find the critical path   [10]

Ans: (ii) 35 days (iii) B–d_2 - C - F - d_3 - G - I – J

14. 2061 Q.No. 8 (b)

Find the normal cost and duration of project and also find the time cost trade off points that are possible and the cost of the project after crashing the activities.   [10]

Activities	Pre-requisite activity	Time (week)		Cost in '000' (Rs.)	
		Normal	Crash	Normal	Crash
A	None	8	6	8	10
B	None	7	5	6	8.4
C	A	5	4	7	8.5
D	B	4	3	3	3.8
E	A	3	2	2	2.6
F	D, E	5	3	5	6.6
G	C	4	3	6	7

Ans: cost of the project after crashing = Rs. 43,900, Normal cost = Rs. 37,000; minimum project completion time = 13 weeks.

15. 2060 Q.No. 8 (b)

Draw a network diagram for the following and determine the minimum time required to complete project. Also find the critical path of the project.   [10]

Activities	A	B	C	D	E	F	G	H	I	J	K	L	M
Predecessor	–	–	B	C	A,D	D	A,D	E	G,H	I	G	J,K	L
Expected time (in weeks)	12	10	4	4	4	2	12	10	12	4	8	6	2

Ans: minimum time to complete project = 56 weeks, critical path B-C-d-E-H-I-J-L-M.

16. 2059 Q.No. 8 (b)

Construct a PERT network for the following schedule of project.

Activities	A	B	C	D	E	F	G	H	I	J	K	L
Predecessor	None	None	A	B	B	C,D	E	E	G	H,I	I,J	F
Time	8	2	1	9	4	5	6	3	3	5	2	3

Compute ES, LS and slack time for each activities and find the critical path.   [10]

Ans: Critical path B-D-F-L; project length = 19

17. 2058 Q.No. 9 (a)

Construct a PERT network diagram and identity the critical activities and show that the slack time of the critical activities will be equal to zero by computing slack time for each activity.   [10]

PERT (time estimates) in Weeks

Activities	A	B	C	D	E	F	G	H	I	J
Predecessor	None	A	B	C	B	E	C	D	G, H	F, I
Most likely	8	9	20	13	11	25	12	8	7	6
Most pessimistic	10	13	25	16	13	25	17	10	7	6
Most optimistic	6	8	15	10	9	25	10	7	7	6

Ans: Critical path A-B-C-D-H-I-J; Project length = 71.67 weeks.

MBA

18. 2056 Q.No. 5 (b)

The following list of activities must be accomplished in order to complete a construction project. Construct the diagram and complete the expected project completion time.   [10]

Activities	A	B	C	D	E	F	G	H	I	J
Time (weeks)	3	8	4	2	7	5	6	8	9	
Predecessors	None	None	A, B	B	A	C	E, F	D, F	G, H	I

Ans: Expected project completion time = 42 weeks, Critical path, B - d1 - C - F - d2 - H - I - J

19. 2054 Q.No. 7 (b)

Find the time cost trade off points that are possible. What is the minimum time in which the project can be completed? What is the cost of the program for the project activities, which are given below: [10]

Activity (i - j)	Name of Activity	Time (week)		Cost (Rs.)	
		Normal	Crash	Normal	Crash
(1 - 2)	A	5	3	200	300
(1 - 3)	B	2	1	50	70
(2 - 4)	C	3	2	180	220
(3 - 4)	D	4	2	300	450
(2 - 5)	E	4	3	420	550
(4 - 6)	F	3	1	100	150
(5 - 6)	G	5	4	600	700

Ans: Minimum project completion time = 10 weeks, Total project cost = Rs. 2,180

20. 2053 Q.No. 7 (b)

The following are the list of activities and sequencing requirements along with expected time of completion of the various activities of a project.

Activities	A	B	C	D	E	F	G	H	I	J	K	L	M
Pre-requisites activity	-	-	B	C	A,D	D	A,D	E	G,H	I	G	J,K	L
Expected time (weeks)	6	5	2	2	2	1	6	5	6	2	4	3	1

Draw a network diagram and determine the minimum time to compete the project pointing out the various bottleneck activities.   [10]

Ans: minimum time to complete the project 28 weeks.

21. 2046 Q.No. 6 (b)

A project is composed of ten activities and three estimates are listed in the following table. Draw a PERT diagram and determine the critical path and also compute the slack time.

Activity	Immediately preceding activities	Time estimates (Days)		
		Most optimistic	Most pessimistic	Most likely
A	–	1	5	3
B	A	3	8	4
C	B	10	20	15
D	C	5	11	8
E	B	4	8	6
F	E	20	20	20
G	C	5	12	7
H	D	2	5	3
I	G, H	2	2	2
J	F, I	1	1	1

Ans: Critical path, A - B- C - D - H - I - J. Project length = 36.67 days

22. 2045 Q.No. 6 (b)

A project has the following characteristic.

Activity	Most Optimistic time	Most likely time	Most Pessimistic time	Predecessors
A	0.5	1	2	None
B	1	2	3	A
C	1	3	5	A
D	3	4	5	B
E	2	3	4	C
F	3	5	7	C
G	4	5	6	D, E
H	6	7	8	F
I	2	4	6	G, H
J	5	6	8	G,H
K	1	2	3	I
L	3	5	7	J

Construct a PERT network and compute the critical path. [10]

Ans: Critical path A - C - F - H - J - L Expected project length = 27.25

23. 2041 Q.No. 6 (b)

Draw a project network and identify the critical path and project length of the project having nine time activities, whose time estimates are listed below: [10]

Activity (i - j)	1 - 2	1 - 3	1 - 4	2 - 5	3 - 5	4 - 6	5 - 6	6 - 7	5 - 7
Optimistic (t_n)	1	3	2	1	3	2	4	6	3
Most likely (t_m)	1	5	2	1	6	5	6	8	7
Pessimistic (t_p)	7	7	8	1	9	8	14	10	11

Ans: Critical path B - E - G- H; Project length = 26

24. 2039 Q.No. 9 (b)

A project has the following schedule:

Predecessors	None	None	A	B	B	C, D	E	F	G	H	I,J	F
Activity	A	B	C	D	E	F	G	H	I	J	K	L
Time (monthly)	4	1	1	1	6	5	4	8	1	2	5	7

Construct a PERT network and compute ES, AS and slack time for each activity, find the critical path. [10]

Ans: Critical path B - E - H - J - K; project length = 22 months

11. GAME THEORY

1.   2068 Q.No. 8

Find optimal strategies by using dominance rule for A and B in the following game. Also obtain the value of the game.   [10]

		Player B		
		B₁	B₂	B₃
Player	A₁	1	7	2
	A₂	6	2	7
	A₃	5	2	6

Ans: Optimal Strategy: A = $\left(\frac{2}{5}, \frac{3}{5}, 0\right)$, B = $\left(\frac{1}{2}, \frac{1}{2}, 0\right)$ and Value of the game = 4

2.   2067 Q.No. 8b

Determine the saddle point solution, the associated pure strategies, and the value of the game for each of the following games. The pay offs are for player A

		Player B			
		B₁	B₂	B₃	B₄
Player A	A₁	8	6	2	8
	A₂	8	9	4	5
	A₃	7	5	3	5

Ans: Saddle point is A₂B₃; value of game = 4