CBCS SCHEME

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15ME81

Eighth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Operations Research

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. State various phases of operations research and explain in brief any one of them. **(06 Marks)**

b. Four products are processed successively on two machines. The machining times in hours per unit of each product are given below:

Machine	Time per unit (hr.)			
	Product 1	Product 2	Product 3	Product 4
1	2	3	4	2
2	3	2	1	2

The total cost of producing one unit of each product is based directly on machine time. Cost per hour for machines 1 and 2 are Rs.10 and Rs.5 respectively. The total hours available for machines 1 and 2 are 500 and 380. If the sale price per unit for products 1, 2, 3 and 4 are Rs.65, 70, 55 and 45 respectively, formulate as LPP to maximize total net profit. **(10 Marks)**

OR

2 a. Define Optimum solution, Feasible zone, redundant constraint. **(06 Marks)**

b. Feasible zone ABCDEA, identified by a set of constraints of a LPP having 2 decision variables x, y has A ≡ (1, 0); B ≡ (1, 2); C ≡ (2, 3), D ≡ (4, 1); E ≡ (2, 0). If a new constraint $x \leq 2y$ is added, identify the new feasible zone (show on graph). State redundant constraints. Find maximum and minimum value of Z if Z = 3x + 5y for new feasible zone. **(10 Marks)**

Module-2

3 a. Define Slack variable, Surplus variable and Artificial variable. **(06 Marks)**

b. For the LPP,

Maximize $Z = 2x_1 - 5x_2 + 10x_3$

Subject to $x_1 + 2x_2 + 2x_3 \leq 90$

$x_1, x_2, x_3 \geq 0$

i) Find all basic solutions and obtain optimum solution.
ii) Find the optimum solution by simplex.
iii) Write the dual for the given LPP. **(10 Marks)**

OR

4 Solve the following LPP

Maximize $Z = x_1 + 2x_2 + 3x_3$

Subject to $x_1 - x_2 + x_3 \geq 4$

$x_1 + x_2 + 2x_3 \leq 8$

$x_1 - x_3 \geq 2$

$x_1, x_2, x_3 \geq 0$ **(16 Marks)**

Module-3

5 a. Write a brief note on 'Degeneracy in Transportation Problem'. **(06 Marks)**

b. As the total demand is more than the total supply, it is not possible to meet the demand of every destination of the transportation problem given below:

		Destination A	B	C	
Source	1	5	1	7	10
	2	6	4	6	80
	3	3	2	5	15
		75	20	50	

The penalty cost per unit of unsatisfied demand are Rs.5, 3 and 2 for destinations A, B and C respectively.

i) Formulate the problem to minimize the total (transportation plus penalty) cost.

ii) Obtain basic feasible solution by VAM.

iii) Test the basic feasible solution for optimality. **(10 Marks)**

OR

6 a. State the common and distinguishing features of Transportation Problem and Assignment Problem. **(06 Marks)**

b. Solve the following assignment problem:

	I	II	III	IV	V
A	11	17	8	16	20
B	9	7	12	6	15
C	13	16	15	12	16
D	21	24	17	28	26
E	14	10	12	11	13

(10 Marks)

Module-4

7 a. Define Network, Event, Dummy activity. **(06 Marks)**

b. For the network shown in Fig.Q7(b), the three time estimates for the activities are given along the arrows. Determine the critical path. What is the probability that the project will be completed in 20 days?

Z	0.45	0.47	0.48	0.49	0.50
Ψ(z)	0.6736	0.6808	0.6844	0.6879	0.6915

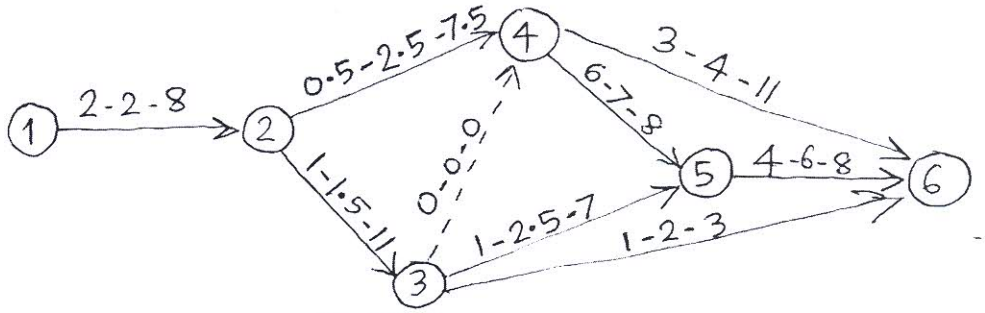

Fig.Q7(b)

(10 Marks)

OR

8 a. State and explain in brief Kendall's notation for representing queing models. **(06 Marks)**

b. A self service store employs one cashier at its counter. Nine customers arrive on an average every 5 minutes while the cashier can serve 10 customers in 5 minutes. Assuming Poisson distribution for arrival and exponential distribution for service, find

i) Average number of customers in the system

ii) Average number of customers in the queue

iii) Average time a customer spends in the system

iv) Average time a customer waits before being served. **(10 Marks)**

Module-5

9 a. Define Saddle point, Zero Sum game, Game Value. **(06 Marks)**

b. Reduce the game to either m × 2 or 2 × n by dominance, and then solve graphically.

		B			
		B_1	B_2	B_3	B_4
A	A_1	19	6	7	5
	A_2	7	3	14	6
	A_3	12	8	18	4
	A_4	8	7	13	–1

(10 Marks)

OR

10 a. State assumptions made while applying Johnson's rule to 'n jobs on 2 machines'. **(06 Marks)**

b. Use graphical method to minimize the time required to process the following jobs on the machines. For each machine specify the job which should be done first. Also calculate the total elapsed time.

Job 1	Sequence	A	B	C	D	E
	Time (hr)	6	8	4	12	4
Job2	Sequence	B	C	A	D	E
	Time (hr)	10	8	6	4	12

(10 Marks)

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10ME74

Seventh Semester B.E. Degree Examination, June/July 2019
Operations Research

Time: 3 hrs. Max. Marks:100

Note:1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. Areas under the standard normal distribution (statistical table).

PART – A

1 a. A Farmer has 100 acre farm. He can sell all tomatoes, lettuce or radishes he can raise. The price he can obtain is Rs. 1.00 per kg tomatoes, Rs. 0.75 a head for lettuce and Rs. 2.00 per kg for radishes. The average yield per acre is 2,000 kg of tomatoes, 3,000 heads of lettuce, and 1000 kgs of radishes. Fertilizer is available at Re.0.50 per kg and the amount required per acre is 100 kgs each for tomatoes and lettuce and 50 kgs for radishes. Labour required for sowing, cultivating and harvesting per acre is 5-man-days for tomatoes and radishes and 6 man-days for lettuce. A total of 400 man-days are available at Rs.20 per man-day. Formulate this problem as a linear programming model to maximize the farmer's total profit. **(10 Marks)**

b. Solve the following LP problem graphically :

$$\text{Max } z = 8000x_1 + 7000x_2$$

Subject to $3x_1 + x_2 \le 66$

$x_1 + x_2 \le 45$

$x_1 \le 20,\ x_2 \le 40$

and $x_1, x_2 \ge 0$. **(10 Marks)**

2 a. Use BIG-M method to maximize $Z = 3x_1 - x_2$

Subject to $2x_1 + x_2 \le 2$

$x_1 + 3x_2 \ge 3$

$x_2 \le 4$

$x_1, x_2 \ge 0$. **(10 Marks)**

b. Obtain the dual of the following primal problem:

Minimize $z = 3x_1 - 2x_2 + x_3$

Subject to $2x_1 - 3x_2 + x_3 \le 5$

$4x_1 - 2x_2 \ge 9$

$-8x_1 + 4x_2 + 3x_3 = 8$.

$x_1, x_2 \ge 0$, x_3 is unrestricted. **(10 Marks)**

3 a. Find the optimal solution to the following:
Transportation problem shown in Table Q3 (a) in which the calls contain the transportation. Cost in Rupees. **(10 Marks)**

		To Ware houses					
		W_1	W_2	W_3	W_4	W_5	Available
From	F_1	7	6	4	5	9	40
	F_2	8	5	6	7	8	30
	F_3	6	8	9	6	5	20
	F_4	5	7	7	8	6	10
	Required	30	30	15	20	5	

Table Q3 (a)

3 b. Solve the following Assignment problem shown in Table Q3 (b). **(10 Marks)**

	I	II	III	IV	V
1	11	17	8	16	20
2	9	7	12	6	15
3	13	16	15	12	16
4	21	24	17	28	26
5	14	10	12	11	13

Table Q3 (b)

4 a. What is integer programming problem, and methods adopted to solve them? **(05 Marks)**

b. Solve the following integer programming problem, using Gomary's fractional cutting plane method.

Maximize $z = x_1 + 2x_2$

Subject to Constraints $2x_2 \leq 7$

$x_1 + x_2 \leq 7$

$2x_1 \leq 11$

$x_1, x_2 \geq 0$ and are integers. **(15 Marks)**

PART – B

5 a. A project has the following time schedule, shown in Table Q5 (a).

Activity	1–2	1–3	1–4	2–5	3–6	3–7	4–6	5–8	6– 9	7–8	8–9
Duration (in months)	2	2	1	4	8	5	3	1	5	4	3

Table Q5 (a)

(i) Construct PERT network.

(ii) Compute Total float, Free float and Independal float for each activity.

(iii) Critical path and its duration. **(10 Marks)**

b. A small project is composed of seven activities whose time estimates are listed in Table Q5 (b).

(i) Draw the project network.

(ii) Find the critical path.

(iii) Find the probability of the project being completed within 19 weeks. **(10 Marks)**

Activity	Estimated Direction in Weeks		
	Optimistic most likely		Pessimistic
	a	m	b
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

Table Q5 (b)

6 a. What are the elements of a queuing system (structure of queuing system)? **(05 Marks)**

b. A self service stores employs one cashier at its counter. Nine customers arrive on an average every 5 minutes, while the cashier can serve 10 customers in 5 minutes. Assuming poisson's distribution for arrival rate and exponential distribution for service time. Find :

(i) Arrival and service rate per minute.

(ii) Average number of customer in the system.

(iii) Average number of customers in the queue or Average queue length.

(iv) Average time a customer spends in the system.

(v) Average time a customer waits before being served. **(15 Marks)**

7 a. Explain, what is theory of Games, and based on what principle Neumann forward it also state characteristics of games. **(10 Marks)**

b. Solve the following 2×5 game by graphical method, refer Table Q7 (b). **(10 Marks)**

			Player B				
			1	2	3	4	5
Player A	x_1	1	-5	5	0	-1	8
	$x_2 = 1 - x_1$	2	8	-4	-1	6	-5

Table Q7 (b)

8 a. What are the assumptions in sequencing problems? **(05 Marks)**

b. There are 5 jobs, each of which is to be processed through three machines A, B and C in the order ABC. Determine the optimum sequence for the 5-jobs and the minimum elapsed time. Also find the idle time for the three machines refer the Table Q8 (b) for machining time in hours. **(15 Marks)**

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

Table Q8 (b)

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10ME74

Seventh Semester B.E. Degree Examination, Dec.2018/Jan.2019
Operations Research

Time: 3 hrs. Max. Marks:100

Note: *1. Answer any FIVE full questions, selecting atleast TWO questions from each part.*
2. Use of normal distribution chart is permitted.

PART – A

1 a. List and explain different phases of operations research. **(06 Marks)**

b. Solve the following LP problem graphically :

Minimize $z = 2x_1 + 1.5x_2$

Subject to $x_1 + x_2 = 50$

$0.15x_1 - 0.05x_2 \geq 0$

$0.02x_1 - 0.03x_2 \geq 0$

$-0.05x_1 + 0.15x_2 \geq 0$

$x_1, x_2 \geq 0.$ **(14 Marks)**

2 a. Solve the following LPP by Big-M method :

Minimum $Z = 2x_1 + x_2$

Subject to $3x_1 + x_2 = 3$

$4x_1 + 3x_2 \geq 6$

$x_1 + 2x_2 \leq 3$

$x_1, x_2 \geq 0.$ **(15 Marks)**

b. Write the dual of the following LPP :

maximum $Z = 3x_1 + 2x_2 + 1x_3$

subject to $5x_1 + 2x_2 + 3x_3 = 6$

$2x_1 + 3x_2 + x_3 \geq 2$

$x_1 + 2x_2 + 6x_3 = 5$

$x_1, x_2, x_3 \geq 0.$ **(05 Marks)**

3 a. Obtain basic feasible solution for the following transportation problem by

i) North–West corner rule
ii) Matrix minima method
iii) Penalty method. **(10 Marks)**

To / Form	1	2	3	4	5	Capacity
A	5	8	6	6	3	800
B	4	7	7	6	5	500
C	8	4	4	6	4	900
Demand	400	400	500	400	800	

b. Solve the travelling salesman problem for the following data :

$C_{12} = 20$ $C_{13} = 4$ $C_{14} = 10$ $C_{35} = 6$ $C_{23} = 5$ $C_{25} = 10$ $C_{34} = 6$ $C_{54} = 20$

Where $C_{ij} = C_{ji}$ and there is no route between cities i and j the values for C_{ij} is not given.

(10 Marks)

4 Solve the following integer programming problem by Gomory cutting plane method :
Maximum $Z = 3x_1 + 4x_2$
Subject to $2x_1 + x_2 \leq 6$
$2x_1 + 3x_2 \leq 9$
$x_1, x_2 \geq 0$ and integers. **(20 Marks)**

PART – B

5 a. Explain the Fulkerson rule of numbering of nodes with the help of an example. **(05 Marks)**

b. A project consists of the activities as given in the table below :

Activity	Immediate predecessor	Time in weeks		
		t_0	t_p	t_ℓ
A	–	1	7	1
B	A	1	7	4
C	–	2	8	2
D	B, C	1	1	1
E	C	2	14	5
F	A, C	2	8	5
G	D	3	15	6

i) Draw the project network and find the critical path. **(10 Marks)**
ii) What is the probability of completing the project in 17 weeks? **(05 Marks)**

6 a. Briefly explain the characteristics of queue. **(06 Marks)**

b. A barbar runs a one-man shop. Customers arrive on FCFS basis follows a Poisson pattern with a mean arrival rate of 30/hour. The barbar's service time appears to be exponentially distributed with a mean of 1.5 minute. Determine :
i) The expected number of customers in the shop
ii) The expected number of customers waiting for service
iii) The average time a customer should expect to wait for service
iv) The probability that the service is idle. **(14 Marks)**

7 a. Briefly explain the following terms with reference to game theory :
i) Saddle point ii) Pure strategy iii) Pay-off iv) Mixed strategy. **(08 Marks)**

b. Two players A and B playing matching coins game in which each player has 4 coins ; a 1 Rs, a 2 Rs., a 5 Rs and a 10 Rs. Each player selects a coin without the knowledge of others choice. If the sum of the coins amount is an odd, player–A wins player–B's coin. If the sum the coins amount is even, B wins A's coin. Formulate this problem as game theory problem and find the optimal strategies for each player and game value. **(12 Marks)**

8 a. Briefly explain the Johnson algorithm for finding the sequence for 'n' jobs through 2 machines. **(04 Marks)**

b. Find the sequence that minimizes the total elapsed time required to complete the following tasks :

Task	A	B	C	D	E	F	G
Time on M/c-1(Hrs)	3	8	7	4	9	8	7
Time on M/c-2(Hrs)	4	3	2	5	1	4	3
Time on M/c-3(Hrs)	6	7	5	11	5	6	12

Also find the percentage of utilization and idle time of each machine. **(16 Marks)**

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10ME74

Seventh Semester B.E. Degree Examination, June/July 2018
Operations Research

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer FIVE full questions, selecting at least TWO questions from each part.*
2. *Hand book / Charts / Tables are not permitted.*

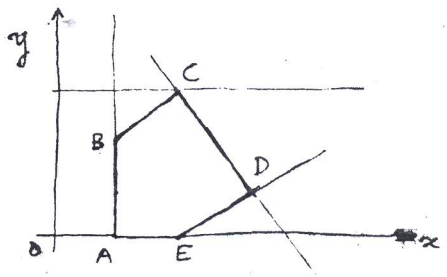
PART – A

1 a. Four products are processed successively on two machines. The manufacturing times in hours per unit of each product are tabulated below:

Machine	Time per unit (hr)			
	Product 1	Product 2	Product 3	Product 4
1	2	3	4	2
2	3	2	1	2

The total cost of producing one unit of each product is based directly on the machine time. Cost per hour for machines 1 and 2 is Rs. 10 and 5 respectively. The total hours available on machines 1 and 2 are 500 and 380. If the sales price per unit for products 1, 2, 3 and 4 are Rs. 65, 70, 55 and 45 respectively, formulate the problem as a LPP to maximize total net profit. **(10 Marks)**

b. Feasible zone ABCDE identified by a set of constraints is shown in Fig. Q1 (b). If a constraint $x \le 2y$ is added, identify the new feasible zone. Also identify and state all redundant constraints.



Co-ordinates of,
A ≡ (1, 0)
B ≡ (1, 2)
C ≡ (2, 3)
D ≡ (4, 1)
E ≡ (2, 0)

Fig. Q1 (b)

Determine maximum and minimum value of Z if $z = 3x + 5y$, after the inclusion of additional constraint. **(10 Marks)**

2 a. Solve the following LPP by Big-M method.

Min $z = 4x_1 + x_2$

Subject to constraint $3x_1 + x_2 = 3$

$4x_1 + 3x_2 \ge 6$.

$x_1 + 2x_2 \le 4$

$x_1, x_2 \ge 0$ **(10 Marks)**

b. Consider the following LPP.

Max. $z = 5x_1 - 6x_2 + 12x_3$

Subject to constraint $x_1 + 3x_2 + 3x_3 \le 90$ and $x_1, x_2, x_3 \ge 0$

(i) Find all basic solutions and thus obtain the optimum solution.
(ii) Find the optimum solution by simplex method.
(iii) Write the dual for the given primal. **(10 Marks)**

3 a. For the following unbalanced transportation problem, penalty costs per unit of unsatisfied demand are Rs. 5, 3 and 2 for destinations 1, 2 and 3 respectively. Find the optimum solution. (12 Marks)

	Destination 1	2	3	
O_1	5	1	7	10
O_2	6	4	6	80
O_3	3	2	5	15
	75	20	50	

b. Solve the following assignment problem for maximization. (08 Marks)

		Area A_1	A_2	A_3	A_4
Salesman	S_1	200	150	170	220
	S_2	160	120	150	140
	S_3	190	195	190	200
	S_4	180	175	160	190

4 Solve the following problem using cutting plane algorithm:

Max. $z = 200x_1 + 300x_2$

Subject to constraint : $2x_1 + 4x_2 \leq 17$

$3x_1 + 3x_2 \leq 15$

$x_1, x_2 \geq 0$ and integer. (20 Marks)

PART – B

5 a. In order to construct network, a project has been represented as shown in Fig. Q5 (a). Can it be considered as a network? If can not be considered, then state the rules which have been violated? (08 Marks)

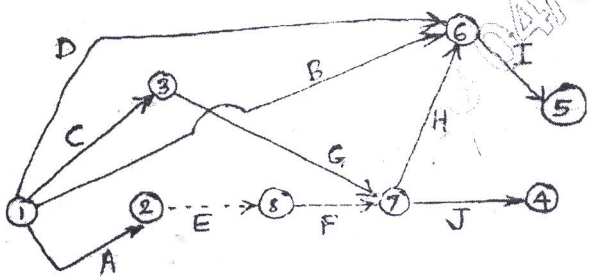


Fig. Q5 (a)

b. A project consists of twelve activities (A to L) with the following precedence:

(i) A, B, C are first ones and can start simultaneously.
(ii) A, B < D
(iii) B < E, F, H
(iv) F, C < G
(v) E, H < I, J
(vi) C, D, F, J < K
(vii) K < L

Duration of activities are listed below:

Activity:	A	B	C	D	E	F	G	H	I	J	K	L
Duration (days):	6	4	10	1	1	3	14	6	9	2	7	5

Construct the network and find the critical path and also duration of project. (12 Marks)

6 a. Explain in brief the following terms related to 'Service discipline', with example:
(i) First In First Out (ii) Last In First Out (iii) Priority service
(iv) Random service. **(08 Marks)**

b. The number of customers approaching the tailor appear to be Poisson distributed with a mean of 6 customers per hour. The tailor attends the customers on FIFO basis. The tailor can attend the customers at an average of 10 per hour with the service time exponentially distributed. Find
(i) The average idle time of tailor on a 10-hour working day.
(ii) The expected number of customers waiting for tailor's services.
(iii) Probability of having exactly 3 customers in the tailor's shop.
(iv) Probability of having 3 or less customers in the shop. **(12 Marks)**

7 a. Use dominance to reduce the following game to 2×2 and then solve. **(08 Marks)**

		B			
		B_1	B_2	B_3	B_4
A	A_1	3	2	4	0
	A_2	3	4	2	4
	A_3	4	2	4	0
	A_4	0	4	0	8

b. Solve the following game graphically,

		B			
		1	2	3	4
A	A_1	2	2	3	-1
	A_2	4	3	2	6

If the given problem possesses multiple optimum solutions, find two solutions. **(12 Marks)**

8 a. Determine the optimal sequence of performing 5 jobs on 4 machines. The machining of each job is in the order ABCD and machining times are as follows:

	Machine			
Job	A (hr)	B (hr)	C (hr)	D (hr)
1	8	3	4	7
2	9	2	5	5
3	6	4	5	8
4	12	5	1	9
5	7	1	2	3

Also find the optimum time to complete all jobs. **(10 Marks)**

b. Using graphical method, determine the minimum time needed to process the two jobs on six machines. The information about the machine sequence and the time required by each job is given below: **(10 Marks)**

Job 1

Order:	A	B	C	D	E	F
Time (hr)	4	5	1	3	6	5

Job 2

Order:	B	A	C	F	D	E
Time (hr)	6	3	2	4	3	5

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10ME74

Seventh Semester B.E. Degree Examination, Dec.2017/Jan.2018
Operations Research

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of normal distribution tables is permitted.***

PART – A

1 a. Define operations research. Give the historical development of operations research. **(06 Marks)**

b. A farmer has 100 acre land. He can sell all the tomatoes, lettuce or radishes that he can raise. The price he can obtain is ₹ 10/- per kg of tomatoes, ₹ 7/- a head of lettuce and ₹ 10/- per kg of radishes. The average yield per acre is 2000 kg of tomatoes, 3000 heads of lettuce and 1000 kg of radishes. Labour required for Sowins, Cultivating and harwesting per acre is 5 man-days for tomatoes and radishes and 6 man-days for lettuce. A total of 400 man-days of labour is available at ₹ 100/- per man day. Formulae this problem as LPP to maximize the farmer's profit. **(08 Marks)**

c. Define the following terms with reference to LPP:
(i) Feasible solution. (ii) Infeasible solution. (iii) Unbounded solution. **(06 Marks)**

2 a. Explain the concepts of degeneracy in simplex method. **(05 Marks)**

b. Solve the following LPP using simplex method,

$$z_{min} = x_1 - 3x_2 + 2x_3$$

Subject to: $3x_1 - x_2 + 2x_3 \le 7$

$$-2x_1 + 4x_2 \le 12$$

$$-4x_1 + 3x_2 + 8x_3 \le 10$$

$$x_1, x_2, x_3 \ge 0$$

(15 Marks)

3 a. Larsen and Toubro company needs 3, 3, 4 and 5 million cubic feet of fill at four earthen dam sites I, II, III and IV in Karnataka. It can transfer the fill from three mounds A, B, C where 2, 6, 7 million cubic feet of fill is available respectively. Costs of transportation of one million cubic feet of fill from mounds to the four sites in lakhs of rupees are given in the following table.

		To I	II	III	IV
From	A	15	10	17	18
	B	16	13	12	13
	C	12	17	20	11

Determine the optimal transportation plan which minimizes the total transportation cost to the company. **(12 Marks)**

b. A batch of 4 jobs can be assigned to 5 different machines. The following table shows the installation time in hours for each job on various machines. Find the optimal assignment of jobs to machines which will minimize the total installation time. **(08 Marks)**

		Machine M_1	M_2	M_3	M_4	M_5
Job	J_1	10	11	4	2	8
	J_2	7	11	10	14	12
	J_3	5	6	9	12	14
	J_4	13	15	11	10	7

4 a. What is an integer programming problem? Explain the importance of integer programming. **(05 Marks)**

b. Use branch and bound method to solve the following integer programming problem:

$Z_{max} = 7x_1 + 9x_2$

Subject to,

$-x_1 + 3x_2 \le 6$

$7x_1 + x_2 \le 35$

$x_2 \le 7$

$x_1, x_2 \ge 0$ and are integers. **(15 Marks)**

PART – B

5 a. Explain the basic steps involved in PERT/CPM. **(04 Marks)**

b. Write short notes on crashing of a project network. **(04 Marks)**

c. An organization has large number of activities but it is interested in controlling a part of these activities to 7 in number. The following data is available for these activities.

Activity	Precedence	Time (days)		
		t_0	t_m	t_p
A	-	4	6	8
B	A	6	10	14
C	A	8	15	22
D	B	9	9	9
E	C	10	14	18
F	A	5	5	5
G	D, E, F	8	10	12

(i) Draw a PERT network for the activities.

(ii) Identify the critical path and its duration.

(iii) If the organization puts 47 days as dead line to complete, what is the probability of completion in 47 days. **(12 Marks)**

6 a. Define the term queue. State and explain the characteristics of queing system. **(08 Marks)**

b. Patrons arrive at a reception counter at an average inter arrival time of 2 minutes. The receptionist on duty takes an average of one minute per person. (Arrivals are as per exponential and services are as per Poisson distribution).

(i) What is the probability that a person will straight away meet the receptionist?

(ii) For what portion of the time the receptionist is busy?

(iii) What is the average queue length?

(iv) What is the average number of patrons in the system?

(v) What is the average waiting time of a patron?

(vi) What is the average time a patron spends in the system? **(12 Marks)**

7 a. Explain the following terms related to theory of games:

(i) Pay-off matrix.

(ii) Min.Max and Max.Min principle.

(iii) Dominance rule.

(iv) Pure and mixed strategies.

(v) Fair game. **(10 Marks)**

b. Use the dominance rule and solve the following game whose pay.off matrix for player A is:

		B		
		B_1	B_2	B_3
A	A_1	-4	6	3
	A_2	-3	-3	4
	A_3	2	-3	4

(10 Marks)

8 a. List out any four assumptions underlying sequencing problems. **(04 Marks)**

b. Consider the processing times (in minutes) of 5 jobs each of which must undergo through 2 machines M_1 and M_2 in the order M_1M_2.

		Job				
		J_1	J_2	J_3	J_4	J_5
Machine	M_1	5	1	9	3	10
	M_2	2	6	7	8	4

Obtain the sequence for the jobs that minimizes the total elapsed time and also find the idle time of both the machines. **(08 Marks)**

c. There are five jobs, each of which is to be processed through machines A, B and C in the order CAB, processing time in hours is given below:

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

Determine the optimum sequence for the jobs and the total elapsed time. **(08 Marks)**

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10ME74

Seventh Semester B.E. Degree Examination, June/July 2017
Operations Research

Time: 3 hrs. Max. Marks:100

Note: *Answer FIVE full questions, selecting atleast TWO questions from each part.*

PART – A

1 a. Explain in brief different phases of operations research. **(06 Marks)**

b. Mention four application areas of operation research. **(04 Marks)**

c. A furniture maker has 6-units of wood and 28 hrs of free time, in which he will make two – models of decorative screens. He estimates that model–1 requires 2-units of wood and 7-hrs of working time, while model-2 requires 1-unit of wood and 8-hrs of working time. The prices of the models are Rs.120/- and Rs. 80/- per screen respectively. Formulate this problem as L.P.P and solve it by graphical method. **(10 Marks)**

2 a. Define :
i) Basic feasible solution
ii) Optimal solution
iii) Un bounded solution. **(06 Marks)**

b. Use the Simplex method to solve following L.P.P
Maximize $Z = 4x_1 + 10x_2$
Subject to $2x_1 + x_2 \leq 50$
$2x_1 + 5x_2 \leq 100$
$2x_1 + 3x_2 \leq 90$
$x_1, x_2 \geq 0$ **(14 Marks)**

3 a. Solve the following transportation problem (minimization)

	D_1	D_2	D_3	D_4	Supply
S_1	21	16	25	13	11
S_2	17	18	14	23	13
S_3	32	27	18	41	19
Demand	6	10	12	15	

i) Find IBFS by VAM method
ii) Check for optimality by MODI method. **(14 Marks)**

b. Find the optimal assignment cost for following assignment problem.

Machine	Operators I	II	III	IV
A	10	5	13	15
B	3	9	18	3
C	10	7	3	2
D	5	11	9	7

(06 Marks)

4 Find the optimum integer solution to following I.P.P

Maximize $Z = x_1 + 2x_2$

Subjected to $x_1 + x_2 \leq 7$

$2x_1 \leq 11$

$2x_2 \leq 7$

$x_1, x_2 \geq 0$ and are integers. **(20 Marks)**

PART – B

5 a. A project consist of activities as given in the table :

Activities	Predecessor	Estimated time in weeks		
		t_0	t_p	t_ℓ
A	–	1	7	1
B	A	1	7	4
C	–	2	8	2
D	B. C	1	1	1
E	C	2	14	5
F	A, C	2	8	5
G	D	3	15	6

i) Draw the project network

ii) Identify the critical path and determine the expected completion time of project

iii) What is the probability that project would be completed in 17 weeks? **(16 Marks)**

b. Draw the graph of direct cost, indirect cost and total cost of a project. Show the optimum duration and least cost of project on graph. **(04 Marks)**

6 a. Briefly explain the important characteristics of queuing system. **(08 Marks)**

b. A box office ticket window manned by single server, customers arrive to purchase tickets according to Poisson's distribution with a mean rate of 30/hr. The time required to serve a customer has an exponential distribution with a mean of 90 sec. Determine :

i) Mean queue length

ii) Mena waiting time in the queue

iii) Probability that there are 3 or more customers in the system

iv) Percentage of time the server is busy. **(12 Marks)**

7 a. Explain :
i) pure strategy
ii) mixed strategy. **(04 Marks)**

b. Find the optimal strategies and value of game by using dominance rule for following game.

$$\begin{bmatrix} -4 & 6 & 3 \\ -3 & -3 & 4 \\ 2 & -3 & 4 \end{bmatrix}.$$

(08 Marks)

c. Solve the following game graphically

		Player B				
		B_1	B_2	B_3	B_4	B_5
Player A	A_1	2	−1	5	−2	6
	A_2	−2	4	−3	1	0

Find the strategies for player A and B and also value of game. **(08 Marks)**

8 a. Explain the following :
i) idle time on machine
ii) total elapsed time **(04 Marks)**

b. Mention any six assumptions made for sequencing problems. **(06 Marks)**

c. There are 5-jobs each of which must go through the two machines A and B in order A, B processing times are given below :

Jobs	1	2	3	4	5
Time on (hrs) machine A	5	1	9	3	10
Time on (hrs) machine B	2	6	7	8	4

Determine the sequence for 5-jobs that will minimize the total elapsed time. Also calculate minimum elapsed time and idle times for both the machines. **(10 Marks)**

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CRASH COURSE

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10ME74

Seventh Semester B.E. Degree Examination, May 2017
Operation Research

Time: 3 hrs. Max. Marks:100

Note: *1. Answer any FIVE full questions, selecting atleast TWO questions from each part.*
2. Use of statistical tables permitted.

PART – A

1 a. A firm plans to purchase atleast 200 quintals of scrap containing high quality metal 'X' and low quality metal 'Y'. It decides that the scrap to be purchased must contain atleast 100 quintals of X –metal and not more than 35 quintal of Y-metal. The firm can purchase the scrap from two suppliers (A and B) in unlimited quantities. The percentage of X and Y metals interms of weight in the scarps supplied by A and B is given below Table Q1(a).

Metal	Supplier A	Supplier B
X	25%	75%
Y	10%	20%

Table Q1(a)

The price of A's scrap is Rs. 200 per quintal and that of B's is Rs. 400 per quintal. Formulate this problem as LP model and solve graphically to determine the quantities that the firm should buy from the two suppliers so as to minimize total purchase cost. **(14 Marks)**

b. Explain the various principal phases involved in implementing OR study into practice. **(03 Marks)**

c. What are the limitations of OR for its implementation in industries? **(03 Marks)**

2 a. With suitable examples, illustrate the use of slack, surplus and artificial variables in simplex method to solve LP problem. **(06 Marks)**

b. Write the dual of below given primal LP problem :
Min $Z = x_1 + x_2 + x_3$;
Subject to constraints $x_1 - 3x_2 + 4x_3 = 5$
$x_1 - 2x_2 \leq 3$
$2x_2 - x_3 \geq 4$
$x_1, x_2 \geq 0$ and x_3 unrestricted. **(04 Marks)**

c. Solve the below given LP problem using Big-M or penalty method and comment on the obtained optimal solution :
max $Z = 3x_1 + 2x_2$;
subject to constraints : $2x_1 + x_2 \leq 2$
$3x_1 + 4x_2 \geq 12$
$x_1, x_2 \geq 0$. **(10 Marks)**

3 a. A leading firm has three auditors. Each auditor can work upto 160 hours during the next month, during which three projects must be completed. Project 1 will take 130 hours, project 2 will take 140 hours and the project 3 will take 160 hours. the amount per hour that can be billed for assigning each auditor to each project in given in the Table Q3(a) below:

Auditor	Project		
	1(Rs)	2(Rs)	3(Rs)
1	1,200	1,500	1,900
2	1,400	1,300	1,200
3	1,600	1,400	1,500

Table Q3(a)

Formulate this as a transportation problem and find optimal solution. Also, find out the maximum total billings during next month. **(10 Marks)**

b. A private firm employs typists on hourly piece rate basis for their daily work. Five typists are working in that firm and their charges and speeds are different. On the basis of some earlier understanding, only one job is given to one typist and the typist is paid for full hours even when he or she works for a fraction of an hour. Find the least cost allocation for the data listed in Table Q3(b)(i) and Table Q3(b)(ii). **(10 Marks)**

Typist	Rate per hour (Rs)	Number of pages typed per hr
A	5	12
B	6	14
C	3	8
D	4	10
E	4	11

Table Q3(b)(i)

Job	Number of pages
P	199
Q	175
R	145
S	298
T	178

Table Q3(b)(ii)

4 a. Illustrate why integer programming is needed with suitable example. **(04 Marks)**

b. Distinguish between pure and mixed integer programming problems. **(04 Marks)**

c. Solve the below given integer programming problem using Gomory's cutting plane method :

Max $Z = 7x_1 + 9x_2$

Subject to constraints $-x_1 + 3x_2 \leq 6$

$7x_1 + x_2 \leq 35$

$x_1, x_2 \geq 0$ and are integers. **(12 Marks)**

PART – B

5 A project consists of activities as given in the Table Q5(a)(i) below :

Activities job	A	B	C	D	E	F	G	H	I	J	K	L
Duration (days)	13	5	8	10	9	7	7	12	8	9	4	17

And the constraints as listed in TableQ5(a)(ii)

Sl.No.	Constraint
1	A and B are starting jobs
2	A controls CD and E
3	B controls F and J
4	G depends on C
5	H depends on D
6	E and F controls I and L
7	K follows J
8	L is also controlled by K
9	G, H, I and L are last activities

i) Draw activity on arrow (AoA) network for the above project

ii) Find the critical path and project duration

iii) Calculate early start time [EST], early finish time (EFT), late start time (LST), late finish time (LFT) and total float (TF) for each activities. **(20 Marks)**

6 a. An airline's organization has one reservation clerk on duty in its local branch at any given time. The clerk handles information regarding passenger reservation and flight timings. Assume that the number of customers arriving during any given period is Poisson distributed with an arrival rate of eight per hour and that reservation clerk can serve a customer in six minutes on an average, with an exponentially distributed service time.

i) What is the probability that system is busy
ii) What is the average time a customer spends in the system
iii) What is the average length of the queue
iv) What is the average number of customers in the system? **(14 Marks)**

b. Discuss on the limitations for the application of queuing models. **(06 Marks)**

7 a. Explain the following with any suitable examples :

i) Pay off matrix
ii) Two person zero sum game. **(04 Marks)**

b. A and B play a game in which each has three coins i) 5 paise ii) 10 paise and iii) 20 paise. Each selects a coin without the knowledge of the others choice.. If the sum of the coins is an odd amount, player 'A' wins player 'B's coin. If the sum an even amount, then player B wins player A's coin. Formulate the given problem and find best strategy for each player. Also, find value of game. **(08 Marks)**

c. Solve the game given in the TableQ7(c), using graphical method. Also, find alternate solutions, if any : **(08 Marks)**

		B			
		I	II	III	IV
A	I	2	2	3	-1
	II	4	3	2	6

Table Q7(c)

8 a. State the assumptions made while dealing with sequencing problems. **(04 Marks)**

b. A manufacturing company processes six different jobs on two machines A and B in the order AB. Number of units of each job and its processing times on machine A and B are given in Table Q8(b). Find the optimal sequence, the total minimum elapsed time and idle time for either machine. **(08 Marks)**

Job number	Number of units of each job	Processing time	
		Machine A (minute)	Machine B (minutes)
1	3	5	8
2	4	16	7
3	2	6	11
4	5	3	5
5	2	9	7.5
6	3	6	14

Table Q8(b)

c. Use graphical method to minimize the time required to process the jobs given in TableQ8(c) on machines. Calculate the total elapsed time to complete the jobs. For each machine specify the job that should be done first. **(08 Marks)**

		Machines				
Job 1	Sequence	A	B	C	D	E
	Time (hrs)	1	2	3	5	1
Job 2	Sequence	C	A	D	E	B
	Time (hrs)	3	4	2	1	5

Table Q8(c)

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10ME74

Seventh Semester B.E. Degree Examination, Dec.2016/Jan.2017
Operations Research

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART – A

1 a. Briefly explain the scopes of Operation Research. **(05 Marks)**

b. A farmer has 100 acre farm. He can sell all tomatoes, lettuce or radishes and can rise the price to obtain Rs 1.00 per kg for tomatoes, Rs 0.75 a head for lettuce and Rs 2.00 per kg for radishes. The average yield per acre is 2000 kgs of tomatoes, 3000 heads of lettuce and 1000 kgs of radishes. Fertilizers are available at Rs 0.50 per kg and the amount required per acre is 100 kgs each for tomatoes and lettuce and 50 kgs for radishes. Labour required for sowing, cultivating and harvesting per acre is 5 man days for tomatoes and radishes and 6 man days for lettuce. A total of 400 man days of labour are available at Rs 20 per man day. Formulate this problem as a linear programming model to maximize the farmer's total profit. **(15 Marks)**

2 a. Write the dual of the following LPP.

Minimize $Z = 3x_1 - 6x_2 + 4x_3$

Subject to $4x_1 + 3x_2 + 6x_3 \geq 9$

$1x_1 + 2x_2 + 3x_3 \geq 6$

$6x_1 - 2x_2 - 2x_3 \leq 10$

$x_1 - 2x_2 + 6x_3 \geq 4$

$2x_1 + 5x_2 - 3x_3 \geq 6$

$x_1, x_2, x_3 \geq 0.$ **(05 Marks)**

b. Solve the following Linear Programming problem.

Maximize $Z = x_1 + 2x_2 + 3x_3 - x_4$

Subject to $x_1 + 2x_2 + 3x_3 = 15$

$2x_1 + x_2 + 5x_3 = 20$

$x_1 + 2x_2 + x_3 + x_4 = 10$

$x_1, x_2, x_3, x_4 \geq 0.$

Solve by using Two phase method. **(15 Marks)**

3 a. ABC Limited has three production shops supplying a product to 5 warehouses. The cost of production varies from shop to shop, cost of transportation from shop to shop cost of transportation from shop to warehouses also varies. Each shop has a specific production capacity of each warehouse has certain amount of requirement. The cost of transportation are as given below :

Shop	Warehouse					Capacity	Cost of production
	I	II	III	IV	V		
A	6	4	4	7	5	100	14
B	5	6	7	4	8	125	16
C	3	4	6	3	4	175	15
Requirement	60	80	85	105	70		

Find the optimum quantity to be supplied from each shop to different warehouse at minimum cost. **(12 Marks)**

b. A ABC company has 5 tasks and 5 persons to perform. Determine the optimal assignment that minimizes the total cost. **(08 Marks)**

Jobs	Machines				
	A	B	C	D	E
P	6	7	5	9	4
Q	7	5	10	9	6
R	5	4	3	6	5
S	8	3	5	6	4
T	4	7	5	6	6

4 a. Explain the importance of integer programming. **(05 Marks)**

b. Solve the following linear programming by Gomory technique :

Maximize $Z = x_1 + x_2$

Subject to $2x_1 + x_2 \leq 6$

$4x_1 + 5x_2 \leq 20$

$x_1 x_2 \geq 0$ and integers. **(15 Marks)**

PART – B

5 a. Define the following terms with reference to PERT :

i) Total float ii) Free float iii) Independent float. **(06 Marks)**

b. A project schedule has the following characteristics.

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

i) Draw the network and find the critical path.

ii) Compute EST, EFT, LST, LFT, total float for each activity. **(14 Marks)**

6 a. Briefly explain queuing system and its characteristics. **(06 Marks)**

b. Arrival rate of telephone call at a telephone booth are according to Poisson distribution, with an average time of 9 minutes between two consecutive arrivals. The length of telephone call is assumed to be exponentially distributed with mean 3 minutes.

i) Determine the probability that a person arriving at the booth will have to wait.

ii) Find the average queue length.

iii) The telephone company will install a second booth when convinced that an arrival would expect to have to wait at least 4 minutes for the phone. Find the increase in flow rate of arrivals which will justify a second booth.

iv) What is the probability that he will have to wait for more than 10 minutes before the phone is free? **(14 Marks)**

7 a. Solve the following game by Graphical method. **(14 Marks)**

		B				
		1	2	3	4	5
A	1	3	0	6	-1	7
	2	-1	5	-2	2	1

b. Use Dominance Rule to find the optimum strategies for both the player. **(06 Marks)**

	B_1	B_2	B_3	B_4	B_5	B_6
A_1	4	2	0	2	1	1
A_2	4	3	1	3	2	2
A_3	4	3	7	−5	1	2
A_4	4	3	4	−1	2	2
A_5	4	3	3	−2	2	2

8 a. Define i) Total elapsed time ii) Idle time. **(04 Marks)**

b. Find the sequence that minimized the total time required in performing the job on 3 machines in the order CBA. **(16 Marks)**

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

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Seventh Semester B.E. Degree Examination, Dec.2016/Jan.2017
Operations Research

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART – A

1 a. Briefly explain the scopes of Operation Research. **(05 Marks)**

b. A farmer has 100 acre farm. He can sell all tomatoes, lettuce or radishes and can rise the price to obtain Rs 1.00 per kg for tomatoes, Rs 0.75 a head for lettuce and Rs 2.00 per kg for radishes. The average yield per acre is 2000 kgs of tomatoes, 3000 heads of lettuce and 1000 kgs of radishes. Fertilizers are available at Rs 0.50 per kg and the amount required per acre is 100 kgs each for tomatoes and lettuce and 50 kgs for radishes. Labour required for sowing, cultivating and harvesting per acre is 5 man days for tomatoes and radishes and 6 man days for lettuce. A total of 400 man days of labour are available at Rs 20 per man day. Formulate this problem as a linear programming model to maximize the farmer's total profit. **(15 Marks)**

2 a. Write the dual of the following LPP.

Minimize $Z = 3x_1 - 6x_2 + 4x_3$

Subject to $4x_1 + 3x_2 + 6x_3 \geq 9$

$1x_1 + 2x_2 + 3x_3 \geq 6$

$6x_1 - 2x_2 - 2x_3 \leq 10$

$x_1 - 2x_2 + 6x_3 \geq 4$

$2x_1 + 5x_2 - 3x_3 \geq 6$

$x_1, x_2, x_3 \geq 0.$ **(05 Marks)**

b. Solve the following Linear Programming problem.

Maximize $Z = x_1 + 2x_2 + 3x_3 - x_4$

Subject to $x_1 + 2x_2 + 3x_3 = 15$

$2x_1 + x_2 + 5x_3 = 20$

$x_1 + 2x_2 + x_3 + x_4 = 10$

$x_1, x_2, x_3, x_4 \geq 0.$

Solve by using Two phase method. **(15 Marks)**

3 a. ABC Limited has three production shops supplying a product to 5 warehouses. The cost of production varies from shop to shop, cost of transportation from shop to shop cost of transportation from shop to warehouses also varies. Each shop has a specific production capacity of each warehouse has certain amount of requirement. The cost of transportation are as given below :

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B	5	6	7	4	8	125	16
C	3	4	6	3	4	175	15
Requirement	60	80	85	105	70		

Find the optimum quantity to be supplied from each shop to different warehouse at minimum cost. **(12 Marks)**

b. A ABC company has 5 tasks and 5 persons to perform. Determine the optimal assignment that minimizes the total cost. **(08 Marks)**

Jobs	Machines				
	A	B	C	D	E
P	6	7	5	9	4
Q	7	5	10	9	6
R	5	4	3	6	5
S	8	3	5	6	4
T	4	7	5	6	6

4 a. Explain the importance of integer programming. **(05 Marks)**

b. Solve the following linear programming by Gomory technique :

Maximize $Z = x_1 + x_2$

Subject to $2x_1 + x_2 \leq 6$

$4x_1 + 5x_2 \leq 20$

$x_1\ x_2 \geq 0$ and integers. **(15 Marks)**

PART – B

5 a. Define the following terms with reference to PERT :

i) Total float ii) Free float iii) Independent float. **(06 Marks)**

b. A project schedule has the following characteristics.

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

i) Draw the network and find the critical path.

ii) Compute EST, EFT, LST, LFT, total float for each activity. **(14 Marks)**

6 a. Briefly explain queuing system and its characteristics. **(06 Marks)**

b. Arrival rate of telephone call at a telephone booth are according to Poisson distribution, with an average time of 9 minutes between two consecutive arrivals. The length of telephone call is assumed to be exponentially distributed with mean 3 minutes.

i) Determine the probability that a person arriving at the booth will have to wait.

ii) Find the average queue length.

iii) The telephone company will install a second booth when convinced that an arrival would expect to have to wait at least 4 minutes for the phone. Find the increase in flow rate of arrivals which will justify a second booth.

iv) What is the probability that he will have to wait for more than 10 minutes before the phone is free? **(14 Marks)**

7 a. Solve the following game by Graphical method. **(14 Marks)**

		B				
		1	2	3	4	5
A	1	3	0	6	-1	7
	2	-1	5	-2	2	1

b. Use Dominance Rule to find the optimum strategies for both the player. **(06 Marks)**

	B_1	B_2	B_3	B_4	B_5	B_6
A_1	4	2	0	2	1	1
A_2	4	3	1	3	2	2
A_3	4	3	7	−5	1	2
A_4	4	3	4	−1	2	2
A_5	4	3	3	−2	2	2

8 a. Define i) Total elapsed time ii) Idle time. **(04 Marks)**

b. Find the sequence that minimized the total time required in performing the job on 3 machines in the order CBA. **(16 Marks)**

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

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10ME74

Seventh Semester B.E. Degree Examination, June/July 2016
Operations Research

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART – A

1 a. A cargo plane has 3 compartments for storing cargo: front, centre and rear. These compartments have the following limits on both weight and space.

Compartment	Weight capacity (in Tonnes)	Space capacity (in cubic meters)
Front	10	6800
Centre	16	8700
Rear	8	5300

Furthermore, the weight of the cargo in the respective compartments must be the same proportion of that compartment's weight capacity to maintain the balance of the plane. The following four cargoes are available for shipment on the next flight:

Cargo	Weight (Tonnes)	Volume (Cubic meters)	Profit (£/Tonne)
C_1	18	480	310
C_2	15	650	380
C_3	23	580	350
C_4	12	390	285

Any proportion of these cargoes can be accepted. The objective is to determine how much of each cargo C_1 , C_2 , C_3 and C_4 should be accepted and how to distribute each among the compartments so that the total profit for the flight is maximized.
Formulate the above problem as a linear program. **(10 Marks)**

b. Solve the following problem using graphical method.
Maximize $Z = 2x_1 + 3x_2$
Subject to $2x_1 + x_2 \le 6$
$x_1 - x_2 \ge 3$
$x_1 , x_2 \ge 0$ **(10 Marks)**

2 a. Solve the following linear programming problem using simplex method.
Maximize $Z = 6000x_1 + 4000x_2$
Subject to $4x_1 + 3x_2 \le 360$
$2x_1 + x_2 \le 160$
$2x_1 + 3x_2 \le 300$
$x_1 , x_2 \ge 0$ **(12 Marks)**

b. Solve by dual simplex method the following problem.
Minimize $Z = 2x_1 + 2x_2 + 4x_3$
Subject to $2x_1 + 3x_2 + 5x_3 \ge 2$
$3x_1 + x_2 + 7x_3 \le 3$
$x_1 + 4x_2 + 6x_3 \le 5$
$x_1 , x_2 , x_3 \ge 0$ **(08 Marks)**

3 a. A product is produced by four factories A, B, C & D. The unit production counts in them are A – 50 units; B – 70 units; C – 30 units and D – 50 units. These factories supply the product to four stores, demands of which are 25, 35, 105 and 20 units respectively. Unit transport cost in Rupees from each factory to each store is given below.

	1	2	3	4
A	2	4	6	11
B	10	8	7	5
C	13	3	9	12
D	4	6	8	3

Determine the extent of deliveries from each factory to each of the stores so that the total production and transportation cost is minimum. **(12 Marks)**

b. Four new machines M_1, M_2, M_3 & M_4 are to be installed in a machine shop. There are five vacant places A, B, C, D & E. Because of limited place, machine M_2 cannot be placed at C and M_3 cannot be placed at A. C_{ij} , the assignment cost of machine i to place j in dollars is shown below.

	A	B	C	D	E
M_1	4	6	10	5	6
M_2	7	4	-	5	4
M_3	-	6	9	6	2
M_4	9	3	7	2	3

Find the optimum assignment schedule. **(08 Marks)**

4 Solve the following using Gomory's cutting plane algorithm.

Maximize $Z = 20000x_1 + 30000x_2$

Subject to $2x_1 + x_2 \le 6$; $x_1 + 2x_2 \le 8$; $x_1 - x_2 \le 1$; $x_1 \le 2$

$x_1 , x_2 \ge 0$ and are integers. **(20 Marks)**

PART – B

5 a. A project schedule has the following characteristics:

Activity	Time (Weeks)	Activity	Time (Weeks)
1 – 2	4	5 – 6	4
1 – 3	1	5 – 7	8
2 – 4	1	6 – 8	1
3 – 4	1	7 – 8	2
3 – 5	6	8 – 10	5
4 – 9	5	9 – 10	7

i) Construct the network and compute E & L for each event.

ii) Find the critical path and project duration. **(12 Marks)**

b. What are the characteristics of a project? Also define the PERT and crashing cost. **(08 Marks)**

6 a. Define five operating characteristics of a queueing system. **(10 Marks)**

b. A self-service store employs one cashier at its counter. Nine customers arrive on an average every 5 minutes while the cashier can serve 10 customers in 5 minutes. Assuming Poisson distribution for arrival rate and exponential distribution for service time, find

i) Average no. of customers in the system.

ii) Average no. of customers in the queue.

iii) Average time a customer spends in the system.

iv) Average time a customer waits before being served. **(10 Marks)**

7 a. Reduce the following game by dominance and find the game value. **(10 Marks)**

		Player B			
		1	2	3	4
Player A	1	3	2	4	0
	2	3	4	2	4
	3	4	2	4	0
	4	0	4	0	8

b. Solve the following game by the graphical method. **(10 Marks)**

		Player B			
		1	2	3	4
Player A	1	3	3	4	0
	2	5	4	3	7

8 a. Six jobs A, B, C, D, E & F have arrived at one time to be processed on a single machine. Assuming that no new jobs arrive thereafter, determine

Job	A	B	C	D	E	F
Processing Time (in minutes)	7	6	8	4	3	5

i) Optimal sequence as per SPT rule
ii) Completion time of the jobs
iii) Mean flow time
iv) Avg. in process inventory. **(08 Marks)**

b. There are seven jobs, each of which has to go through the machines A & B in the order AB. Processing times in hours are given as

Job	1	2	3	4	5	6	7
Machine A	3	12	15	6	10	11	9
Machine B	8	10	10	6	12	1	3

Determine a sequence of these jobs that will minimize the total elapsed time. Also find the idle time for both the machines. **(12 Marks)**

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10ME74

Seventh Semester B.E. Degree Examination, Dec.2015/Jan.2016
Operations Research

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of Normal distribution tables is permitted.

PART – A

1 a. The following are the two constraints for the LPP under consideration:
$x_1 - x_2 \geq 1$; $x_1 + x_2 \geq 7$; and $x_1, x_2 \geq 0$
using the graphical method, answer the following questions:
i) What are the extreme points for the feasible region?
ii) If the problem has an objective function, maximize $z = 3x_1 + x_2$, what is the optimal point?
iii) If the problem has an objective function, minimize $z = 3x_1 + x_2$, what is the optimal point. **(10 Marks)**

b. Solve the following problem using graphical method maximize $Z = 2x_1 + 3x_2$
Subject to constraints : $2x_1 + x_2 \leq 6$; $x_1 - x_2 \geq 3$; $x_1, x_2 \geq 0$ **(06 Marks)**

c. List any four characteristics of a good model. **(04 Marks)**

2 a. Solve the following LPP by Big – M method.
Maximize $Z = 30000x_1 + 20000x_2$
Subject to : $x_2 \leq x_1 + 3$; $x_2 \leq 6$; $x_2 \geq 2$; $x_1 + 2x_2 \leq 18$;
$2x_1 + x_2 \leq 24$ and $x_1, x_2 \geq 0$ **(14 Marks)**

b. Write the dual for the following primal.
Minimize $Z = 25000x_1 + 35000x_2$
Subject to : $50x_1 + 60x_2 = 2500$; $80x_1 + 60x_2 \geq 3000$; $100x_1 + 200x_2 \geq 7000$
Non-negativity constraints : $x_1, x_2 \geq 0$ **(06 Marks)**

3 a. A product is produced by four factories A, B, C & D. The unit production costs in them are ₹2, ₹3, ₹1 and ₹5 respectively. Their production capacities are: Factory A : 50 units ; B : 70 units ; C = 30 units and D : 50 units. These factories supply the product to four stores, the demand of which are 25, 35, 105 and 20 units respectively. Unit transportation cost in rupees from each factory to each store is given in the table below.

		Stores			
		1	2	3	4
Factories	A	2	4	6	11
	B	10	8	7	5
	C	13	3	9	12
	D	4	6	8	3

Determine the extent of deliveries from each of the factories to each of the stores so that the total production and transportation cost is minimum. **(12 Marks)**

b. Four machines M_1 , M_2 , M_3 and M_4 are to be installed in a machine shop. There are five vacant places A, B, C, D and E. Owing to the limitations machine M_2 cannot be placed at C and M_3 cannot be placed at A. The assignment cost of machine i to place j in rupees (1000) is shown below.

	A	B	C	D	E
M_1	4	6	10	5	6
M_2	7	4	-	5	4
M_3	-	6	9	6	2
M_4	9	3	7	2	3

Find the optimal assignment schedule. **(08 Marks)**

4 Solve the below given integer programming problem:

Maximize $Z = 4x_1 + 6x_2 + 2x_3$

Subject to $4x_1 - 4x_2 \leq 5$

$-x_1 + 6x_2 \leq 5$

$-x_1 + x_2 + x_3 \leq 5$

$x_1 , x_2 , x_3 \geq 0$ and x_1 , x_3 are integers. **(20 Marks)**

PART – B

5 Following data refer to a project:

Activity	Immediate Predecessor	Optimistic Time (Hrs)	Most likely Time(Hrs)	Pessimistic Time (Hrs)
A	-	4	6	8
B	-	1	4.5	5
C	A	3	3	3
D	A	4	5	6
E	A	0.5	1	1.5
F	B, C	3	4	5
G	B, C	1	1.5	5
H	E, F	5	6	7
I	E, F	2	5	8
J	D, H	2.5	2.75	4.5
K	G, I	3	5	7

a. Draw the network diagram

b. Find out the ES, EF, LS, LF and slack for each activity.

c. Find out the variance and standard deviation for the critical path.

d. Determine the probability of completing the project in 24 hrs. **(20 Marks)**

6 a. Mention and discuss seven elements of a queing system. **(07 Marks)**

b. Define : (i) Balking (ii) Renegging (iii) Jockeying **(03 Marks)**

c. On an average 96 patients per 24 – hours day require the service of an emergency clinic. On an average a patient requires 10 minutes of active attention. The facility can handle only one emergency at a time. Suppose that it costs the clinic ₹100 per patient treated to obtain an averaging service time of 10 minutes and that each minute of decrease in this average time would cost the clinic ₹10 per patient treated. How much would have to be budgeted by the clinic to decrease the average queue size from $1\frac{1}{3}$ patients to $\frac{1}{2}$ patient? **(10 Marks)**

7 a. What are the characteristics of games? **(04 Marks)**

b. Solve the following game by the dominance rule.

		B's strategy		
		b_1	b_2	b_3
A's Strategy	a_1	12	- 8	- 2
	a_2	6	7	3
	a_3	- 10	- 6	2

Can we formulate the above game as LPP and solve it by simplex / Big-M method? If yes, discuss how? **(08 Marks)**

c. Solve the following game using graphical approach:

		B's Strategy			
		b_1	b_2	b_3	b_4
A's Strategy	a_1	8	5	- 7	9
	a_2	- 6	6	4	- 2

(08 Marks)

8 a. You are given the following data regarding the processing times of some jobs on three machines I, II and III. The order of processing is I – II – III. Determine the sequence that minimizes the total elapsed time required to complete all the jobs. Mention clearly the total elapsed time and the idle time of machine II and III.

Processing Time (Hours)

Job	Machine		
	I	II	III
A	3	4	6
B	8	3	7
C	7	2	5
D	4	5	11
E	9	1	5
F	8	4	6
G	7	3	12

(10 Marks)

b. Madan Mathur is the supervisor of legal-copy-express, which provides copy services for downtown Los Angeles law firms. Five customers submitted their orders at the beginning of the week and are as follows. Schedule the jobs as per i) EDD rule ii) SPT rule and iii) Slack-time remaining per operation rule. Which rule gives the best result in terms of mean-flow-time?

Job (In order of arrival)	A	B	C	D	E
Processing Time (Days)	3	4	6	2	1
Due date (Days hence)	5	6	7	9	2

(10 Marks)

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06ME74

Seventh Semester B.E. Degree Examination, Dec.2015/Jan.2016
Operations Research

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer FIVE full questions, selecting at least TWO questions from each part.*
2. *Use of tables is permitted.*

PART – A

1 a. Define operations research and explain briefly the phases of operations research study. **(05 Marks)**

b. Consider the production details of a machine shop as given in the table:

Products	Processing time in minutes		Profit / unit in □
	Machine M_1	Machine M_2	
A	1	2	3/-
B	1	1	4/-
Available processing time/day	450 min	600 min	

i) Formulate the problem as an LPP.
ii) Determine graphically how many units of A & B should be produced to maximize the total profit. **(10 Marks)**

c. Determine graphically what type of solution is obtained for the following LPP:

Maximize $z = 2x_1 + 3x_2$

ST: $x_1 - x_2 \le 0$

$x_1 \le 4$

and $x_1, x_2 \ge 0$ **(05 Marks)**

2 a. What is linear programming? Define slack, surplus and artificial variables. **(04 Marks)**

b. Solve the following LPP by Big M method:

Minimize $z = 12x_1 + 20x_2$

ST: $6x_1 + 8x_2 \ge 100$

$7x_1 + 12x_2 \ge 120$

and $x_1, x_2 \ge 0$ **(12 Marks)**

c. Write the dual of the following primal:

Maximize $z = 3x_1 + 5x_2$

ST : $2x_1 + 6x_2 \le 50$

$3x_1 + 2x_2 \le 35$

$5x_1 - 3x_2 \le 10$

$x_2 \le 20$

and $x_1, x_2 \ge 0$ **(04 Marks)**

3 a. What is meant by 'penalty' in VAM? What is its significance? **(02 Marks)**

b. Consider the following transportation problem:
Note : Cell entries in Rupees.

		To			Supply
		1	2	3	
From	A	5	1	7	10
	B	6	4	6	80
	C	3	2	5	15
Demand		75	20	50	

If the penalty costs for every unsatisfied demand unit are Rs.5, 3 and 2 for destinations 1, 2 and 3 respectively. Determine the optimal solution. **(10 Marks)**

c. Solve the following travelling salesman problem:
Note : Cell entries in Rupees **(08 Marks)**

		To city			
		1	2	3	4
From city	1	0	30	80	50
	2	40	0	140	30
	3	40	50	0	20
	4	70	80	130	0

4 a. Determine the optimum sequence for the five jobs and the minimum elapsed time. Also find the idle time for the three machines. **(10 Marks)**

Jobs		1	2	3	4	5
Processing	A	3	8	7	5	4
time in Hrs	B	4	5	1	2	3
on Machines	C	7	9	5	6	10

b. Determine graphically the optimal scheduling to minimize the total processing time for the two jobs. Find the total elapsed time. For each machine, specify the job that should be done first. **(10 Marks)**

Job 1	Sequence Time (Hrs)	C	A	E	F	D	B
		2	3	4	5	6	1
Job 2	Sequence Time (Hrs)	B	A	E	F	C	D
		3	2	5	3	2	3

PART – B

5 a. Explain 'service channels' and 'service displine' with respect to queuing systems. **(06 Marks)**

b. A self-service restaurant employs one cashier at its counter. Nine customers arrive on an average every five minutes while the cashier can serve ten customers in five minutes. Assuming Poisson distribution for arrival rate and exponential distribution for service time, find

i) Average number of customers in the system.
ii) Average number of customers in the queue.
iii) Average time a customer spends in the system.
iv) Average time a customer waits.
v) Utilization factor.
vi) Probability of waiting for more than 4 minutes. **(14 Marks)**

6 a. The precedence relationships of tasks in a project are: A < D; A < E; B < F; D < F; C < G; C < H; F < I; G < I.
The time in days for each task are:

Task:	A	B	C	D	E	F	G	H	I
Time:	8	10	8	10	16	17	18	14	9

Draw a network to represent the project and find the minimum time of completion of the project. Also identify the critical path. **(10 Marks)**

b. The time estimates in weeks for the activities of a PERT network are given below:

Activity	1 – 2	1 – 3	1 – 4	2 – 5	3 – 5	4 – 6	5 – 6
t_0	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

i) Draw the project network.
ii) Determine the expected project length.
iii) Calculate the standard deviation and variance of the project length.
iv) What is the probability that the project will be completed at least 4 weeks earlier than expected time? **(10 Marks)**

7 a. Reduce the following game by dominance and find the game value. **(10 Marks)**

		Player B			
		I	II	III	IV
Player A	1	3	2	4	0
	2	3	4	2	4
	3	4	2	4	0
	4	0	4	0	8

b. Solve the following (2×5) game by graphical method: **(10 Marks)**

		Player B				
		1	2	3	4	5
Player A	I	-5	5	0	-1	8
	II	8	-4	-1	6	-5

8 a. Define the following terms:
i) Pure integer programming problem.
ii) Mixed integer programming problem.
iii) Zero-one programming problem. **(03 Marks)**

b. Solve the following problem using Gomory's cutting plane method:
Maximize $z = 5x_1 + 7x_2$
ST : $-2x_1 + 3x_2 \le 6$
$6x_1 + x_2 \le 30$
$x_1, x_2 \ge 0$ and integer. **(17 Marks)**

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10ME74

Seventh Semester B.E. Degree Examination, June/July 2015
Operations Research

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. ***Use of statistical tables is permitted.***

PART - A

1 a. List and briefly explain the various phases of O.R. study and state the limitations of O.R. models. **(10 Marks)**

b. The XYZ Company has been a producer of electronic circuits for Television sets and certain printed circuit boards for Radios. The company has decided to expand into full scale production and marketing of AM and AM - FM radios. It has built a new plant that can operate 48 hours per week. Production of an AM radio in the new plant will require 2 hours and production of AM. FM radio will require 3 hours. Each AM radio will contribute Rs 40 to profit, while an AM – FM radio will contribute Rs 80 to profits. The marketing department , after extensive research, has determined that a maximum of 15 AM radio, and 10AM – FM radios can be sold each week. Formulate a L.P. model to determine the optimal production mix of AM and AM – FM radios that will maximize profits and solve the problem using Graphical method. **(10 Marks)**

2 a. Obtain the Dual problem of the following Primal problem

Min $Z = 2x_1 - 5x_2 - 2x_3$

Subject to $3x_1 - 1x_2 + 2x_3 \leq 9$

$2x_1 - 4x_2 \geq 14$

$-4x_1 + 3x_2 + 8x_3 = 12$

$x_1, x_2 \geq 0$ and x_3 is unrestricted. **(04 Marks)**

b. Use BIG – M method to solve the following LPP

Min $Z = 2x_1 + x_2$

Subject to $3x_1 + x_2 = 3$

$4x_1 + 3x_2 \geq 6$

$x_1 + 2x_2 \leq 3$

$x_1, x_2 \geq 0.$ **(16 Marks)**

3 a. The owner of a machine shop has four machines available to assign the jobs for the day. Five jobs are offered with the expected profit in ₹ for each machine on each job is as follows. Find the assignment of the machines to the jobs that will result in a maximum profit, which job to be declined. **(10 Marks)**

	A	B	C	D	E
1	62	78	50	101	82
2	71	84	61	73	59
3	87	92	111	71	81
4	48	64	87	77	80

b. Solve the following Travelling, Salesman problem given by the following data $C_{12} = 20$, $C_{13} = 4$, $C_{14} = 10$, $C_{23} = 5$, $C_{34} = 6$, $C_{25} = 10$, $C_{35} = 6$, $C_{45} = 20$ when $C_{ij} = C_{ji}$ and C_{ij} value is not given, then there is no route between Cities i and j. **(10 Marks)**

4 a. List and briefly explain the methods of Integer programming problem. **(06 Marks)**

b. Solve the following I.P.P.

Max. $Z = x_1 + x_2$

Subject to $3x_1 + 2x_2 \leq 12$

$x_2 \leq 2$

$x_1, x_2 \geq 0$ and integers. **(14 Marks)**

PART – B

5 a. A project consists of the following activities with their duration in days and the precedence relationship.

Activity	A	B	C	D	E	F	G	H	I
Precedence	-	A	A	B, C	A	D, E	C	F, G	H
Duration (days)	10	12	5	7	9	10	8	10	9

i) Draw the network for the above information ii) Identify the critical path and duration iii) Calculate EST, EFT, LST, LFT, TF. **(10 Marks)**

b. A project schedule has the following characteristics :

Activity	1-2	2-3	2-4	3-5	4-5	4-6	5-7	6-7	7-8	7-9	8-10	9-10
t_m	2	2	3	4	3	5	5	7	4	6	2	5
t_o	1	1	1	3	2	3	4	6	2	4	1	3
t_p	3	3	5	5	4	7	6	8	6	8	3	7

i) Draw a project work, identify the critical path and its expected duration and variance.

ii) What is the probability of completing the project in 30 day schedule time?

iii) What due data has 90% chance of being met? **(10 Marks)**

6 a. Briefly explain characteristics of the Queuing system and classification of queuing models using KENDAL and LEE notations. **(10 Marks)**

b. Arrivals at a Telephone booth are considered to be Poisson distribution at an average time of 8min between one arrival and the next. The length of the phone call is distributed exponentially with a mean of 4min. Determine

i) Expected fraction of the day that the phone will be in use ii) Expected number of units in the queue iii) What is the probability that an arrival will have to wait more than 6min in queue for service? iv) What is the probability that more than 5 units are in the system? **(10 Marks)**

7 a. Define and briefly explain the following terms with respect to GAME theory.

i) PURE STRATEGY ii) SADDLE POINT iii) VALUE OF GAME iv) TWO PERSON ZERO SUM GAME v) PAY – OFF. **(10 Marks)**

b. Solve the following TWO PERSON ZERO SUM GAME by Graphical Method. **(10 Marks)**

		B				
		I	II	III	IV	V
A	1	-5	5	0	-1	8
	2	8	-4	-1	6	-5

8 a. When passing is not allowed, solve the following problem giving an optimal solution. **(10 Marks)**

		Machine				
		M_1	M_2	M_3	M_4	M_5
JOB	A	9	7	4	5	11
	B	8	8	6	7	12
	C	7	6	7	8	10
	D	10	5	5	4	8

b. Find the sequence that minimized the total time required in performing the job on 3 machines in the order CBA. **(10 Marks)**

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

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10ME74

Seventh Semester B.E. Degree Examination, Dec.2014/Jan.2015

Operations Research

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Define operations research. Explain the phases of operations research. **(06 Marks)**

b. A firm manufactures two products A and B on which the profit earned per unit are ` 3 and ` 4 respectively. Each product is processed on two machines M_1 and M_2. Product A requires one minute of processing time on M_1 and two minutes on M_2 while B requires one minute on M_1 and one minute on M_2. Machine M_1 is available for not more than 7 hrs. 30 mins while machine M_2 is available for 10 hrs during any working day. Find the number of units of product A and B to be manufactured to get maximum profit. **(14 Marks)**

2 a. Solve the following LPP using simplex method:

Maximize $Z = 3x_1 + 2x_2$

Subject to constraints $x_1 + x_2 \le 4$

$x_1 - x_2 \le 2$

$x_1, x_2 \ge 0$ **(10 Marks)**

b. Solve the given problem by using Big-M method:

Maximize $Z = -2x_1 - x_2$

Subject to constraints $3x_1 + x_2 = 3$

$4x_1 + 3x_2 \ge 6$

$x_1 + 2x_2 \le 4$ and

$x_1, x_2 \ge 0$. **(10 Marks)**

3 a. ABC limited has three production shops supplying a product to 5 warehouses. The cost of production varies from shop to shop, cost of transportation from shop to shop, cost of transportation from shop to warehouses also varies. Each shop has a specific production capacity of each warehouse has certain amount of requirement. The cost of transportation are as given below:

Shop	Warehouse					Capacity	Cost for production
	I	II	III	IV	V		
A	6	4	4	7	5	100	14
B	5	6	7	4	8	125	16
C	3	4	6	3	4	175	15
Requirement	60	80	85	105	70		

Find the optimum quantity to be supplied from each shop to different warehouse at minimum cost. **(12 Marks)**

b. A ABC company has 5 tasks and 5 persons to perform. Determine the optimal assignment that minimizes the total cost.

Jobs	Machines				
	A	B	C	D	E
P	6	7	5	9	4
Q	7	5	10	9	6
R	5	4	3	6	5
S	8	3	5	6	4
T	4	7	5	6	6

(08 Marks)

4 a. Explain the importance of integer programming. **(05 Marks)**

b. Solve the following linear programming by Gomory technique:

Maximize $Z = x_1 + x_2$

Subject to $2x_1 + x_2 \leq 6$

$4x_1 + 5x_2 \leq 20$

$x_1, x_2 \geq 0$ and integers. **(15 Marks)**

PART – B

5 a. Define the following:

i) Normal time

ii) Crash time

iii) Free float **(06 Marks)**

b. R and D activity has 7 activities for which the three time estimates are given below along with its preceding activity.

Activity	Preceeding activity	Optimistic time (a)	Most likely time (m)	Pessimistic time (b)
A	-	4	6	8
B	A	6	10	12
C	A	8	18	24
D	B	9	9	9
E	C	10	14	18
F	A	5	5	5
G	D, E, F	8	10	12

i) Draw PERT network.

ii) Find EST, LST and slack for each node.

iii) Find critical path and expected project duration. **(14 Marks)**

6 a. Briefly explain queuing system and its characteristics. **(06 Marks)**

b. Arrival rate of telephone call at a telephone booth are according to Poisson distribution, with an average time of 9 minutes between two consecutive arrivals. The length of telephone call is assumed to be exponentially distributed, with mean 3 minutes.

i) Determine the probability that a person arriving at the booth will have to wait.

ii) Find the average queue length.

iii) The telephone company will install a second booth when convinced that an arrival would expect to have to wait at least four minutes for the phone. Find the increase in flow rate of arrivals which will justify a second booth.

iv) What is the probability that he will have to wait for more than 10 minutes before the phone is free? **(14 Marks)**

7 a. Explain clearly the following terms:
i) Pay off matrix
ii) Saddle point
iii) Fair game **(06 Marks)**

b. Use dominance rule to find the optimum strategies for both the player. **(07 Marks)**

	B_1	B_2	B_3	B_4	B_5	B_6
A_1	4	2	0	2	1	1
A_2	4	3	1	3	2	2
A_3	4	3	7	−5	1	2
A_4	4	3	4	−1	2	2
A_5	4	3	3	−2	2	2

c. Solve the game by graphical method: **(07 Marks)**

	b_1	b_2
a_1	1	−3
a_2	3	5
a_3	−1	6
a_4	4	1

8 a. Define: (i) Total elapsed time, (ii) Idle time. **(04 Marks)**

b. List the assumption made while dealing with sequencing problem. **(04 Marks)**

c. We have five jobs each of which must go through the machines A, B and C in the order ABC. Determine a sequence for job that will minimize the total elapsed time and idle time for each machine. **(12 Marks)**

Job number	Processing time in hours				
	1	2	3	4	5
Machine A	5	7	6	9	5
Machine B	2	1	4	5	3
Machine C	3	7	5	6	7

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06ME74

Seventh Semester B.E. Degree Examination, June / July 2014
Operations Research

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of normal distribution tables is permitted.***

PART – A

1 a. Explain the characteristics of operations research. **(06 Marks)**

b. Explain in brief various types of models. **(06 Marks)**

c. An institution is planning to organize seminars for the next five days. There is arrangement of dinner on each day. The requirement of napkins during the five days are as follows:

Days	1	2	3	4	5
Minimum napkins required	75	60	110	65	125

The institute does not have any napkins in the beginning. After five days, the institute has no more use of napkins. A new napkin costs Rs.4.00, washing charges for a used one is Rs.1.50. A napkin given for washing after the dinner on first day is returned on third day before dinner and so on. The institute decided to accumulate the used napkins and send them for washing just in time to be used when they return. Formulate this as a linear programming model to minimize the total cost of napkins. **(08 Marks)**

2 a. Define slack and artificial variable. **(03 Marks)**

b. With an example prove that the dual of the dual is primal. **(05 Marks)**

c. Solve the following LPP using simplex method. Also determine the alternate optimal solution if any.

Maximize $z = 2000x_1 + 3000x_2$

Subject to $6x_1 + 9x_2 \le 100$

$2x_1 + x_2 \le 20$

$x_1, x_2 \ge 0$ **(12 Marks)**

3 a. Find the optimal solution for the following transportation problem to minimize the total cost. **(10 Marks)**

		Warehouse W_1	W_2	W_3	Supplies
Plants	P_1	7	6	9	20
	P_2	5	7	3	28
	P_3	4	5	8	17
Demands		21	25	19	

b. Five machines are to be assigned to five jobs. The cost of assigning each job to each machine is given in the following matrix. Which machine to be assigned to which job to minimize the total cost of assignment? **(10 Marks)**

Machine \ Jobs	J_1	J_2	J_3	J_4	J_5
M_1	11	17	8	16	20
M_2	9	7	12	6	15
M_3	13	16	15	12	16
M_4	21	24	17	28	26
M_5	14	10	12	11	15

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

4 a. List any four assumptions made in sequencing. **(04 Marks)**

b. What do you mean by degeneracy in transportation problem? How do you resolve it? **(06 Marks)**

c. Six jobs are to be processed on three machines A, B and C in the order ABC. The processing times in hours of each job on three machines is given below. Find the optimum sequence of jobs, minimum elapsed time and idle time for each machine **(10 Marks)**

Jobs	Processing on A	Processing on B	Processing on C
1	8	3	8
2	3	4	7
3	7	5	6
4	2	2	9
5	5	1	10
6	1	6	9

PART – B

5 a. Explain any four characteristics of queuing system. **(08 Marks)**

b. Arrival rate at a telephone booth are considered to be Poisson with an average time of ten minutes between one arrival and the next. The length of the phone call is assumed to be distributed exponentially with mean 3 minutes.

(i) What is the probability that a person arriving at the booth will have to wait?

(ii) What is the average length of queue?

(iii) The telephone department will install a second booth when convinced that an arrival would expect waiting for at least three minutes for phone. By how much should the flow of arrivals increase in order to justify a second booth? **(12 Marks)**

6 a. Define slack, float and critical path. **(06 Marks)**

b. A project is composed of seven activities whose three time estimates (in weeks) are listed below.

Activity	1 – 2	1 – 3	2 – 4	2 – 5	3 – 5	4 – 6	5 – 6
Optimistic time	1	1	2	1	2	2	3
Most likely time	1	4	2	1	5	5	6
Pessimistic time	7	7	8	1	14	8	15

i) Draw the network.

ii) Compute the expected duration and variance of each activity.

iii) Compute the expected project length and variance of the project length.

iv) Compute the probability that the project will be completed 4 weeks earlier than expected.

v) Compute the probability that the project will be completed 4 weeks later than expected. **(14 Marks)**

7 a. Define the following: i) Pure strategy ii) Mixed strategy iii) Saddle point. **(06 Marks)**

b. Solve the following game and state the optimum strategies: **(06 Marks)**

		Player B		
		B_1	B_2	B_3
Player A	A_1	1	7	2
	A_2	6	2	7
	A_3	6	1	6

c. Solve the following game by graphical method. **(08 Marks)**

		Player B				
		B_1	B_2	B_3	B_4	B_5
Player A	A_1	-5	5	0	-1	8
	A_2	8	-4	-1	6	-5

8 a. Define pure and mixed integer programming problems. **(04 Marks)**

b. Explain the significance of integer programming problems. **(06 Marks)**

c. Explain the iterative procedure of Gommory's cutting plane method. **(10 Marks)**

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2. Use of statistical tables permitted.

PART – A

1 a. List and explain the various phases of OR problems. **(06 Marks)**

b. What are the limitations of OR? **(04 Marks)**

c. A manufacturer of a line of patent medicines is preparing a production plan on medicines A and B. There are sufficient ingredients available to make 20,000 bottles of 'A' and 40,000 bottles of 'B'. But three are only 45,000 bottles into which either of the medicines can be put. Furthermore, it takes 3 hours to prepare enough material to fill 1,000 bottles of 'A', it takes 1 hour to prepare enough material to fill 1,000 bottles of 'B' and there are 66 hours available for this operation. The profit is ₹8 per bottle for 'A' and ₹7 per bottle for 'B'. Formulate the problem as a LPP and solve by graphical method. **(10 Marks)**

2 a. Define slack, surplus, and artificial variables. **(06 Marks)**

b. Obtain the dual of the following primal LP problem:

Minimize $Z = x_1 + x_2 + x_3$

Subject to $x_1 - 3x_2 + 4x_3 = 5$; $2x_1 - 2x_2 \le 3$

$2x_2 - x_3 \ge 5$; $x_1, x_2 \ge 0$, x_3 unrestricted. **(04 Marks)**

c. Use Big-M method to solve the following LPP.

Minimize $Z = 4x_1 + 2x_2$

Subject to $3x_1 + x_2 \ge 27$; $-x_1 - 2x_2 \le -21$

$x_1 + 2x_2 \ge 30$; $x_1, x_2 \ge 0$ **(10 Marks)**

3 a. A company has plants A, B and C which have capacity to produce 300, 200 and 500 kg respectively of a particular chemical/day. The production cost per kg in these plants are ₹0.70, ₹0.60 and ₹0.66 respectively. Four bulk consumers have placed orders for the products on the following books;

Consumers	Kg required/day	Price offered ₹/kg
I	400	1.00
II	250	1.00
III	350	1.02
IV	150	1.03

Shipping costs in paise/kg from plants to consumers are given below:

		To consumers			
		I	II	III	IV
From Plants	A	3	5	4	6
	B	8	11	9	12
	C	4	6	2	8

Workout the optimum schedule for the above situation considering all the data given. **(12 Marks)**

b. A company has a team of four salesman and there are four districts where the company wants to start its business. The company estimates that the profit/day is given below. Find the assignment of salesman to districts which gives maximum profit.

		Districts			
		I	II	III	IV
Salesman	A	16	10	14	11
	B	14	11	15	15
	C	15	15	13	12
	D	13	12	14	15

(08 Marks)

4 a. Explain the branch and bound method in integer programming. **(06 Marks)**

b. Use Gomary's fractional cutting plane method to solve the following IPP.

Maximize $Z = x_1 + 4x_2$

Subject to $2x_1 + 4x_2 \leq 7$

$5x_1 + 3x_2 \leq 15$

$x_1, x_2 \geq 0$ and are integers. **(14 Marks)**

PART – B

5 a. List the differences between PERT and CPM. **(05 Marks)**

b. A small project consists of EIGHT activities has the following characteristics.

Activity	Preceeding activity	Time estimates (weeks)		
		t_0	t_m	t_p
A	-	2	4	12
B	-	10	12	26
C	A	8	9	10
D	A	10	15	20
E	A	7	7.5	11
F	B, C	9	9	9
G	D	3	3.5	7
H	E, F, G	5	5	5

(i) Draw the PERT network for the project.

(ii) Determine the critical path and prepare the activity schedule for the project.

(iii) If a 30 week deadline is imposed, what is the probability that the project will be completed within the time limit? **(15 Marks)**

6 a. Briefly explain the queuing system and their characteristics. **(06 Marks)**

b. A postal clerk can service a customer in 3 minutes. The service time is being exponentially distributed. The inter arrival time of customers is also exponentially distributed with an average of 12 minutes during early morning slack period and an average of 5 minutes during the afternoon peak period. Assess the average queue length and the expected waiting time in the queue during the two periods. **(14 Marks)**

7 a. Explain the following:
(i) Pay off matrix (ii) Saddle point (iii) Fair game. **(05 Marks)**

b. Explain the rule of dominance. **(03 Marks)**

c. Use of property of dominance to solve the following game.

A \ B	I	II	III	IV	V	VI
I	0	0	0	0	0	0
II	4	2	0	2	1	1
III	4	3	1	3	2	2
IV	4	3	7	-5	1	2
V	4	3	4	-1	2	2
VI	4	3	3	-2	2	2

(12 Marks)

8 a. State the assumptions made while dealing with sequencing problems. **(04 Marks)**

b. Find the sequence for the following six jobs that will minimize the total elapsed time for the three operations: **(06 Marks)**

Job	1	2	3	4	5	6
Turning (A)	3	12	5	2	9	11
Threading (B)	8	6	4	6	3	1
Knurling (C)	13	14	9	12	8	13
(Time in minutes)						

c. Use graphical method to minimize the time required to process the following jobs on the machines. Calculate the total elapsed time to complete the jobs. For each machine specify the job that should be done first. **(10 Marks)**

	Machines					
Job 1	Sequence :	A	B	C	D	E
	Time (hr) :	6	8	4	12	4
Job 2	Sequence :	B	C	A	D	E
	Time (hr) :	10	8	6	4	12

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