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- iv) The role of the artificial variables in simplex method is
- a) to aid in finding the initial basic feasible solution
 - b) to start phase of simplex table
 - c) to find shadow price for the final simplex table
 - d) none of these.
- v) Multiple serves may be
- a) In parallel
 - b) In series
 - c) In combination of parallel and series
 - d) None of these.
- vi) A mixed strategy game can be solved by
- a) Matrix method
 - b) Algebraic method
 - c) Graphical method
 - d) None of these.
- vii) When maximum and minimum values of the game are same, then
- a) There is a saddle point
 - b) Solution does not exist
 - c) Strategies are mixed
 - d) None of these.

CS/B.Tech (EE (N+O))/SEM-8/EE-802D/M-802F/2010

viii) The number of basic (decision) variables of the general transportation problem is

- a) $m + n - 1$
- b) $m + n + 1$
- c) $m - n + 1$
- d) none of these.

ix) The number of variables in dual equal to

- a) number of constraints in dual
- b) number of variables in primal
- c) number of constraints in primal
- d) none of these.

x) In critical path computation, forward pass determines

- a) earliest occurrence time of events
- b) duration of activity
- c) latest occurrence time of events
- d) all of these.

xi) In an assignment problem, the minimum number of lines covering the all zeroes in the reduced cost matrix of order n can be

- a) At most n
- b) $n + 1$
- c) $n - 1$
- d) At least n .

CS/B.Tech (EE (N+O))/SEM-8/EE-802D/M-802F/2010

xii) Queuing theory deals with the problems of

- a) material handling
- b) reduction of waiting time or idle time
- c) better utilization of man services
- d) effective use of machines
- e) none of these.

xiii) CPM has which of the following time estimates ?

- a) One time estimate
- b) Two time estimate
- c) Three time estimate
- d) Four time estimate
- e) Nil time estimate.

xiv) The relation between average waiting time in the system (W_s) and the average waiting time in queue (W_q) is

given by

a) $W_q = \mu W_s$

b) $W_q = \frac{1}{\mu} W_s$

c) $W_q = W_s + \frac{1}{\mu}$

d) $W_q = W_s - \frac{1}{\mu}$

CS/B.Tech (EE (N+O))/SEM-8/EE-802D/M-802F/2010

GROUP - B**(Short Answer Type Questions)**Answer any *three* of the following. $3 \times 5 = 15$

2. Find the dual of the problem

Maximize, $Z = 2x_1 + 3x_2 - 4x_3$

Subject to $3x_1 + x_2 + x_3 \leq 2$

$-4x_1 + 3x_2 \geq 4$

$x_1 - 5x_2 + x_3 = 5$

 $x_1, x_2, \geq 0$ and x_3 is unrestricted in sign.

3. A company manufactures two products A and B. Each unit of B takes twice as long to produce as one unit of A and if the company was to produce only A, it would have time to produce 2,000 units per day. The availability of the raw material is sufficient to produce 1,500 units per day of both A and B combined. Product B requires a special ingredient, only 600 units can be made per day. If A fetches a profit of Rs. 2 per unit and B a profit of Rs. 4 per unit, find the optimum product max. by graphical method.

4. By graphical method solve the following LPP :

Max. $Z = 3X_1 + 4X_2$

Subject to $5X_1 + 4X_2 \leq 200$

$3X_1 + 5X_2 \leq 150$

$5X_1 + 4X_2 \geq 100$

$8X_1 + 4X_2 \geq 80$

$X_1, X_2 \geq 0.$

CS/B.Tech (EE (N+O))/SEM-8/EE-802D/M-802F/2010

5. Obtain an initial feasible solution to the following TP using the matrix minima method :

	D1	D2	D3	D4	Supply
O1	1	2	3	4	6
O2	4	3	2	0	8
O3	0	2	2	1	10
Demand	4	6	8	6	24

GROUP - C**(Long Answer Type Questions)**Answer any *three* of the following. $3 \times 15 = 45$

6. a) What is an unbalanced transportation problem ? How can it be solved ? Illustrate. 5
- b) Solve the following transportation problem using Vogel's approximation method : 10

Plant	Warehouses				Capacity
	P	Q	R	S	
A	5	1	3	3	34
B	3	3	5	4	15
C	6	4	4	3	12
D	4	1	4	2	19
Demand	21	25	17	17	

7. a) What are the slack, surplus variables and replacement or exchange ratio in an LPP ? Explain with example. 7
- b) Solve the following linear programming problem using simplex method :

$$\text{Maximize : } Z = 6x_1 + 11x_2$$

$$\text{Subject to } 2x_1 + x_2 \leq 104$$

$$x_1 + 2x_2 \leq 76 \text{ and } x_1 \geq 0, x_2 \geq 0$$

8

CS/B.Tech (EE (N+O))/SEM-8/EE-802D/M-802F/2010

8. The project schedule has following characteristics :

Activity Time	Most optimistic Time	Most Likely Time	Most Pessimistic Time
1 - 2	1	2	3
2 - 3	1	2	3
2 - 4	1	3	5
3 - 5	3	4	5
4 - 5	2	3	4
4 - 6	3	5	7
5 - 7	4	5	6
6 - 7	6	7	8
7 - 8	2	4	6
7 - 9	4	6	8
8 - 10	1	2	3
9 - 10	3	5	7

Construct a PERT network and find out the following :

- i) Earliest possible time to complete different stages of the project
 - ii) The latest allowable time for them
 - iii) The critical paths
 - iv) The slack values
 - v) The probability factor for completing the project in 30 weeks.
9. a) What are the costs associated with inventory ? Distinguish between deterministic and stochastic models in inventory theory.

5

CS/B.Tech (EE (N+O))/SEM-8/EE-802D/M-802F/2010

- b) There are four jobs assigned to the machines. Only one job could be assigned to one machine. The amount of time in hours required for the jobs in a machine is given in the following matrix :

Job	Machines				
	P	Q	R	S	T
A	4	3	6	2	7
B	10	12	11	14	16
C	4	3	2	1	5
D	8	7	6	9	6

Find an optimum assignment of jobs to the machines to minimize the total processing time. Also find, for which machine no job is assigned. What is the total processing time to complete the job ?

10

10. a) The table below lists all the activities which together constitute a small engineering project. Calculate the total project duration.

5

Activity	1-2	1-3	1-4	2-5	3-4	4-5	4-6	5-6	5-7	6-7	3-7
Activity Duration	20	23	8	19	16	0	18	0	4	10	24

- b) Write short notes on any two of the following : 2 × 5

- i) Risk associated with projects
- ii) Queuing models
- iii) Project feasibility study.