TYBCA
US05FBCA01 – OPERATIONS RESEARCH
QUESTION BANK

MULTIPLE CHOICE QUESTIONS

UNIT 1

1. Operations research is the application of ____________methods to arrive at the optimal solutions to the problems.
A. economical
B. **scientific**
C. a and b both
D. artistic

2. Feasible solution satisfies __________
A. Only constraints
B. only non-negative restriction
C. **[a] and [b] both**
D. [a],[b] and Optimum solution

3. In Degenerate solution value of objective function _____________.
A. increases infinitely
B. decreases infinitely
C. basic variables are nonzero
D. **One or more basic variables are zero**

4. Minimize Z = ______________
A. –maximize(Z)
B. maximize(-Z)
C. **-maximize(-Z)**
D. none of the above

5. In graphical method the restriction on number of constraint is __________.
A. 2
B. 3
C. not more than 3
D. **none of the above**

6. In graphical representation the bounded region is known as _________ region.
A. Solution
B. **feasible solution**
C. basic solution
D. optimal

7. Graphical optimal value for Z can be obtained from
A. **Corner points of feasible region**
B. corner points of the solution region
C. Both a and c
D. none of the above

8. In LPP the condition to be satisfied is
A. Constraints have to be linear
B. Objective function have to be linear
C. **both [a]and [b]**
D. none of the above

9. The solution to LPP give below is,

$$Max\ Z = 3x_1 + 14x_2 \quad subject\ \ to\ \ x_1 - x_2 \geq 1,\ -x_1 + x_2 \geq 2 \quad where\ \ x_1, x_2 \geq 0$$

A. Unbounded solution
B. Max Z = 14
C. Max Z = 3
D. **Infeasible solution**

10. The solution to LPP give below is ______________

$$Max\ Z = 30x_1 - 15x_2 \quad subject\ \ to\ \ 2x_1 - 2x_2 \leq 2,\ -2x_1 + 2x_2 \leq 2 \quad where\ \ x_1, x_2 \geq 0$$

A. **Unbounded solution**
B. Max Z = 30
C. Max Z = 15
D. Infeasible solution

11. In the definition of LPP m stands for number of constraints and n for number of variables, then which of the following relations hold
A. m = n
B. m ≤ n
C. m ≥ n
D. None of them

12. The linear function of variables which is to be maximized or minimized is called ________

A. constraints
B. basic requirements
C. **objective function**
D. none of them

EXTRA

13. Operation research approach is

A. **Multi-disciplinary**
B. Artificial
C. Intuitive
D. All of the above

14. Operation research analysts do not

A. **Predict future operation**
B. Build more than one model
C. Collect the relevant data
D. Recommend decision and accept

15. Mathematical model of Linear Programming is important because

A. **It helps in converting the verbal description and numerical data into mathematical expression**
B. decision makers prefer to work with formal models
C. it captures the relevant relationship among decision factors
D. it enables the use of algebraic techniques

16. A constraint in an LP model restricts

A. value of the objective function
B. **value of the decision variable**
C. use of the available resources
D. all of the above

17. In graphical method of linear programming problem if the ios-cost line coincide with a side of region of basic feasible solutions we get

A. Unique optimum solution
B. unbounded optimum solution
C. no feasible solution
D. **Infinite number of optimum solutions**

18. A feasible solution of LPP

A. **Must satisfy all the constraints simultaneously**
B. Need not satisfy all the constraints, only some of them
C. Must be a corner point of the feasible region
D. all of the above

19. The objective function for a L.P model is $3x_1+2x_2$, if $x_1=20$ and $x_2=30$, what is the value of the objective function?

A. 0
B. 50
C. 60
D. **120**

20. Maximization of objective function in LPP means

A. Value occurs at allowable set decision
B. **highest value is chosen among allowable decision**
C. none of the above
D. all of the above

21. Alternative solution exist in a linear programming problem when

A. one of the constraint is redundant
B. **objective function is parallel to one of the constraints**
C. two constraints are parallel
D. all of the above

22. Linear programming problem involving only two variables can be solved by _______________

A. Big M method
B. Simplex method
C. **Graphical method**
D. none of these

23. The linear function of the variables which is to be maximize or minimize is called _________

A. Constraints
B. **Objective function**
C. Decision variable
D. None of the abov

24. A physical model is an example of

A. **An iconic model**
B. An analogue model
C. A verbal model
D. A mathematical model

25. If the value of the objective function z can be increased or decreased indefinitely, such solution is called ______________

A. Bounded solution
B. **Unbounded solution**
C. Solution
D. None of the above

26. A model is

A. An essence of reality
B. An approximation
C. An idealization
D. **All of the above**

27. The first step in formulating a linear programming problem is

A. Identify any upper or lower bound on the decision variables
B. State the constraints as linear combinations of the decision variables
C. Understand the problem
D. **Identify the decision variables**

UNIT 2

1. In the simplex method for solving of LPP number of variables can be ______________.

A. Not more than three
B. at least three
C. **at least two**
D. none of them

2. In the simplex method the variable enters the basis if __________________.

A. $Z_j – C_j \geq 0$
B. $Z_j – C_j \leq 0$
C. $\mathbf{Z_j – C_j < 0}$
D. $Z_j – C_j = 0$

3. In the simplex method the variable leaves the basis if the ratio is

A. maximum
B. minimum
C. **0**
D. none of them

4. The _________ variable is added to the constraint of less than equal to type.

A. **slack**
B. surplus
C. artificial
D. basic

5. For the constraint of greater than equal to type we make use of ______________ variable.

A. slack
B. **surplus**
C. artificial
D. basic

6. The coefficient of slack variable in the objective function is _________________.

A. -M
B. +M
C. **0**
D. none of them

7. The coefficient of artificial variable in the objective function of maximization problem is _________.

A. **-M**
B. +M
C. 0
D. none of them

EXTRA

8. The role of artificial variables in the simplex method is

A. to aid in finding an initial solution
B. to find optimal dual prices in the final simplex table
C. to start with Big M method
D. **all of these**

9. For a minimization problem, the objective function coefficient for an artificial variable is

A. **+ M**
B. -M
C. Zero
D. None of these

10. For maximization LPP, the simplex method is terminated when all values

A. **cj –zj ≤ 0**
B. cj –zj ≥ 0
C. cj –zj = 0
D. zj ≤ 0

11. If any value in b - column of final simplex table is negative, then the solution is

A. unbounded
B. **infeasible**
C. optimal
D. None of these

12. To convert ≥ inequality constraints into equality constraints, we must

A. add a surplus variable
B. subtract an artificial variable
C. **subtract a surplus variable and an add artificial variable**
D. add a surplus variable and subtract an artificial variable

13. In the optimal simplex table cj –zj = 0 value indicates

A. unbounded solution
B. cycling
C. **alternative solution**
D. None of these

14. At every iteration of simplex method, for minimization problem, a variable in the current basis is replaced with another variable that has

A. a positive cj –zj value
B. **a negative cj –zj value**
C. cj –zj = 0
D. None of these

15. A variable which does not appear in the basis variable (B) column of simplex table is

A. never equal to zero
B. **always equal to zero**
C. called basic variable
D. None of these

16. To formulate a problem for solution by the simplex method, we must add artificial variable to

A. only equality constraints
B. only > constraints
C. **both A & B**
D. None of these

17. If all xij values in the incoming variable column of the simplex table are negative, then

A. **solution is unbounded**
B. there are multiple solution
C. there exist no solution
D. None of these

18. If an artificial variable is present in the basic variable column of optimal simplex table, then the solution is

A. unbounded
B. **infeasible**
C. optimal
D. None of these

19. If for a given solution, a slack variable is equal to zero, then
A. **the solution is optimal**
B. the solution is infeasible
C. there exist no solution
D. None of these

20. Linear programming problem involving more than two variables can be solved by ______________
A. Simplex method
B. Graphical method
C. Matrix minima method
D. None of these

UNIT 3

1. The TP is said to be unbalanced if ______________.
A. $\sum a_i \neq \sum b_j$
B. $\sum a_i = \sum b_j$
C. m=n
D. m+n-1= no. of allocated cell

2. The initial solution of a transportation problem can be obtained by applying any known method. However, the only condition is that
A. **Rim condition should be satisfied**
B. cost matrix should be square
C. one of the $X_{ij} < 0$
D. None of them

3. In non-degenerate solution number of allocated cell is____________.
A. Equal to m+n-1
B. **Not equal to m+n-1**
C. Equal to m+n+1
D. Not equal to m+n+1

4. From the following methods ___________ is a method to obtain initial solution to Transportation Problem.
A. **North-West**
B. Simplex
C. Hungarian
D. Newton Raphson

5. The Penalty in VAM represents difference between _________ cost of respective row / column.
A. Two Largest
B. **smallest two**
C. largest and smallest
D. none of them

6. Number of basic allocation in any row or column in Assignment Problem can be
A. **Exactly one**
B. at most one
C. at least one
D. none of them

7. North – West corner refers to ____________.
A. **top left corner**
B. top right corner
C. both of them
D. none of them

8. The ______________ method's solution for transportation problem is sometimes an optimal solution itself.
A. NWCM
B. **VAM**
C. LCM
D. Row Minima

9. In Assignment Problem the value of decision variable x_{ij} is____.
A. no restriction
B. two or one
C. **one or zero**
D. none of them

10. If number of sources is not equal to number of destination in Assignment problem then it is called ___________.

A. **unbalanced**
B. symmetric
C. unsymmetric
D. balanced

11. The _____ method used to obtain optimum solution of travelling salesman problem.

A. Simplex
B. **Hungarian**
C. dominance
D. graphical

EXTRA

12. The initial solution of a transportation problem can be obtained by applying any known method. However, the only condition is that

A. the solution be optimal
B. **the rim condition are satisfied**
C. the solution not be degenerate
D. all of the above

13. The dummy source or destination in a transportation problem is added to

A. **satisfy rim condition**
B. prevent solution from becoming degenerate
C. ensure that total cost does not exceed a limit
D. all of the above

14. The occurrence of degeneracy while solving a transportation problem means that

A. total supply equals total demand
B. **the solution so obtained is not feasible**
C. the few allocations become negative
D. none of the above

15. An alternative optimal solution to a minimization transportation problem exists whenever opportunity cost corresponding to unused routes of transportation is:

A. positive and greater than zero
B. **positive with at least one equal to zero**
C. negative with at least one equal to zero
D. all of the above

16. One disadvantage of using North-West Corner Rule to find initial solution to the transportation problem is that

A. it is complicated to use
B. **it does not take into account cost of transportation**
C. it leads to degenerate initial solution
D. all of the above

17. The solution to a transportation problem with m-rows and n-columns is feasible if number of positive allocations are

A. m+n
B. m x n
C. **m + n -1**
D. all of the above

18. The calculation of opportunity cost in the MODI method is analogous to a

A. **cj –zj value for non-basic variable columns in the simplex method**
B. value of a variable in b-column of the simplex method
C. variable in xb-column
D. all of the above

19. If we were to use opportunity cost value for an unused cell to test optimality, it should be

A. equal to zero
B. **most negative number**
C. most positive number
D. all of the above

20. An assignment problem is considered as a particular case of a Transportation problem because

A. the number of rows equals columns
B. all $x_{ij}= 0$
C. all rim conditions are 1
D. **all of above**

21. The purpose of a dummy row or column in an assignment problem is to

A. **obtain balance between total activities and total resources**
B. prevent a solution from becoming degenerate
C. provide a means of representing a dummy problem
D. none of the above

22. The Hungarian method for solving an assignment problem can also be used to solve

A. a transportation problem
B. **a traveling salesman problem**
C. both A and B
D. only B

23. An optimal of an assignment problem can be obtained only if

A. each row and column has only one zero element
B. each row and column has at least one zero element
C. the data are arrangement in a square matrix
D. **none of the above**

24. The method used for solving an assignment problem is called

A. reduced matrix method
B. MODI method
C. **Hungarian method**
D. none of the above

UNIT 4

1. Dynamic programming is a mathematical technique dealing with the optimization of _______ stage decision process.

A. **multi**
B. single
C. both A and B
D. none of them

2. In sequencing if smallest time for a job belongs to machine-1 then that job has to placed ___________ of the sequence.

A. in the middle
B. at end
C. **in the starting**
D. none of them

3. In sequencing the time involved in moving jobs from one machine to another is ________.

A. **negligible**
B. significant
C. positive number
D. none of them

4. ___________ operation is carried out on a machine at a time.

A. Two
B. **only one**
C. atleast one
D. none of them

5. Processing time M_{ij}'s are __________of order of processing the jobs.

A. dependent
B. **independent**
C. negligible
D. none of them

6. Activity which starts only after finishing other activity is called _____________.
- A. dummy
- B. Predecessor
- C. **successor**
- D. none of them

7. Burst and Merge are types of ___________ in networking.
- A. **event**
- B. activity
- C. arrow
- D. tools

8. Activity which does not require any resources or time is called __________.
- A. **dummy**
- B. Predecessor
- C. successor
- D. none of them

9. Event indicates ____________ of activity.
- A. starting
- B. ending
- C. **both A and B**
- D. none of them

10. _____________ is indicated by dotted arrow.
- A. burst event
- B. merge event
- C. **dummy activity**
- D. none of them

11. ______ event represents beginning of more than one activities.
- A. **burst**
- B. merge
- C. dummy
- D. none of them

12. Merge event represents ___________ of two or more events.
- A. beginning
- B. **completion**
- C. splitting
- D. none of them

13. Activity which is completed before starting new activity is called___________.
- A. dummy
- B. **predecessor**
- C. successor
- D. none of them

EXTRA

14. The Objective of network analysis to
- A. **Minimize total project duration**
- B. Minimize total project cost
- C. Minimize production delays, interruption and conflicts
- D. All of the above

15. Network models have advantage in terms of project
- A. Planning
- B. Scheduling
- C. Controlling
- D. **All of the above**

16. The slack for an activity is equal to
- A. LF-LS
- B. EF-ES
- C. **LS-ES**
- D. None of the above

17. The Another term commonly used for activity slack time is
- A. Total float
- B. Free float
- C. independent float
- D. **All of the above**

18. If an activity has zero slack, it implies that
- A. **It lies on the critical path**
- B. It is a dummy activity
- C. The project progressing well
- D. None of the above

19. A dummy activity is used in the network diagram when

A. Two parallel activities have the same tail and head events
B. The chain of activities may have a common event yet be independent by themselves
C. **Both A and B**
D. None of the above

20. While drawing the network diagram , for each activity project, we should look

A. **What activities precede this activity?**
B. What activities follow this activity?
C. What activities can take place concurrently with this activity?
D. All of the above

21. The critical path satisfy the condition that

A. $\mathbf{E_i = L_i}$ **&** $\mathbf{E_j = L_j}$
B. $L_j-E_i=L_i-L_j$
C. $L_j-E_i=L_i-E_j=c$(constant)
D. All of the above

22. If there are in jobs to be performed, one at a time, on each of m machines, the possible sequences would be

A. $\mathbf{(n!)^m}$
B. $(m!)^n$
C. $(n)^m$
D. $(m)^n$

23. Total elapsed time to process all jobs through two machine is given by

A. $\sum_{j=1}^{n} M_{1j} + \sum_{j=1}^{n} M_{2j}$
B. $\boldsymbol{\sum_{j=1}^{n} M_{2j} + \sum_{j=1}^{n} M_{1j}}$
C. $\sum_{j=1}^{n} (M_{1j} + I_{1j})$
D. None of the above

24. The minimum processing time on machine M_1 and M_2 are related as

A. Min t_{1j} = Max t_{2j}
B. Min $t_{1j} \le$ Max t_{2j}
C. **Min** $\mathbf{t_{1j} \ge}$ **Max** $\mathbf{t_{2j}}$
D. Min $t_{2j} \ge$ Max t_{1j}

25. You Would like to assign operators to the equipment that has

A. Most jobs waiting to be processed
B. Job with the earliest due date
C. Job which has been waiting longest
D. **All of the above**

SHORT QUESTIONS (Each of 2 Marks)

UNIT 1

1. Define Operation research.
2. Write down any two scopes of operation research.
3. State phases for formulating the operations research problems.
4. Define i) Solution ii) Basic solution.
5. Define i) Unbounded solution ii) Optimum solution
6. Define feasible solution.
7. Define LPP in the mathematical form.
8. Give any four models of operations research.

Extra

9. What is Linear programming problem?
10. Write the advantages of LPP.
11. Write the limitations of LPP
12. How will you plot inequalities of a LPP?

UNIT 2

1. Define slack variables.
2. Define surplus variables.
3. Define artificial variables.
4. When is Big M method useful ?
5. What is the condition for optimality in simplex table ?
6. What is the condition for entering variable in simplex table ?
7. Write the standard form of LPP for the following LPP:

$$\text{Maximize } Z = 13x_1 + 25x_2$$
$$\text{Subject to } 21x_1 + 3x_2 \le 40, \quad 5x_1 + 2x_2 \le 7, \quad x_1, x_2 \ge 0$$

8. Write the standard form of LPP for the following LPP:

$$\text{Maximize } Z = 3x_1 + 5x_2$$
$$\text{Subject to } 2x_1 + 3x_2 \le 4, \quad 3x_1 + 2x_2 \ge 7, \quad x_1, x_2 \ge 0$$

Extra

9. What is NER while solving LPP by Simplex method?
10. What is the criterion for the entering variable and outgoing variable?
11. What is Replacement ratio while solving LPP by Simplex method
12. What is the criterion for test of optimality?
13. Represent the form of a simplex table.
14. How do you transform key row in a simplex table? Or How will you find the new solution in the Simplex table.
15. State the situation in simplex table which will represent
(i) Unbounded solution (ii) unique optimum solution (iii) alternate optimum solution.

UNIT 3

1. What is transportation problem?
2. Write mathematical form of transportation problem.
3. What is feasible solution and non degenerate solution in transportation problem?
4. What do you mean by balanced transportation problem?
5. What is the Assignment problem?
6. Give mathematical form of assignment problem.
7. What is travelling salesman problem?

Extra

8. What is the difference between Assignment Problem and Transportation Problem?
9. Write steps for North-West Corner Method.
10. Write steps for Matrix Minima Method.

UNIT 4

1. State Bellman's principle of optimality in dynamic programming.
2. In brief explain problem of sequencing.
3. How will you allocate jobs in a sequence if two jobs on first machine have same processing time?
4. Write down any two assumptions used for solving sequencing problem.
5. Define two types of events used in network analysis.
6. What is dummy activity?
7. What is total float?
8. What is free float and independent float?
9. What is successor activity?

Extra

10. Define terms: Activity, Event, Merge Event, Burst Event, Total float, Free float, Independent float, Critical path
11. State Rules for Network Diagram.
12. Write disadvantages of Network techniques.
13. What is Dynamic Programming Problem?
14. State the principle of optimality in dynamic programming.
15. Write assumptions of sequencing problems.

LONG QUESTIONS (>=3 Marks)

UNIT 1

1. Explain the history of operations research.
2. Write the algorithm to solve LPP using Graphical method for maximization of profit.
3. Give the limitations of operations research.
4. Note down the applications of operations research.
5. Write down meanings of operations research.

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

7. A firm manufactures two types of products A and B and sells them at a profit of Rs. 200 on type A and Rs. 300 on type B. each product is processed on two machines G and H. type A requires 1 minute of processing time on G and 2minutes on H; Type B requires 1 minute on G and 1 minute on H. the machine G is available for not more than 6 hours, 40 minutes while H is available for 10 hours during any working day. Formulate this problem as a linear programming problem.

8. A firm manufactures headache pills in two sizes A and B. size A contains 2 grains of aspirin , 5 grains of bicarbonate and 1 grain of codeine. Size B contains 1 grain of aspirin, 8 grains of bicarbonate and 6 grains of codeine. It is found by users that it requires at least 12 grains of aspirin, 74 grains of bicarbonate and 24 grains of codeine for providing immediate effect. It is required to determine the least number of pills a patient should take to get immediate relief. Formulate the problem as a LPP.

9. A carpenter produces two products chairs and tables. Processing of these products is done on two machines A and B. Chair requires 2 hours on machine A and 6 hours on machine B. A table requires 5 hours on machine A and no hours on machine There are 16 hours of time per day available on machine A and 30 hours on machine B. Assuming that the profit per chair is Rs. 20 and Rs. 35 for table. Formulate the problem as LPP in order to determine the number of chairs and tables to be produced so as to maximize the profit.

10. A manufacturer has two machines A and B. He manufactures two products P and Q on these two machines. For manufacturing product P he has to use machine A for 3 hours and machine B for 6 hours, and for manufacturing product Q he has to use machine A for 6 hours and machine B for 5 hours. On each unit of P he earns Rs. 14 and on each unit of Q he earns Rs. 10. How many units of P and Q should be manufactured to get the maximum profit? Each machine cannot be used for more than 2100 hours. Formulate as LPP.

11. Vitamin A and B are found in foods F_1 and F_2. One unit of food F_1 contains three unit of vitamin A and four unit of vitamin B. One unit of food F_2 contains six unit of vitamin A and three unit of vitamin B. One unit of food F_1 and F_2 cost Rs 14 and Rs 20 respectively. The minimum daily requirement (for person) of vitamin A and B is of 80 and100 units. Assuming excess of vitamin is not harmful to health, formulate LPP to obtain optimum mixture of food F_1 and F_2 required to meet the daily demand such that the total cost is minimized.

12. An electronic company is engaged in production of two components C_1 and C_2 used in radio sets. The availability of different aspects and the prices are given below. Formulate as LPP to determine number of components C_1 and C_2 to be produced so as to maximize the profit.

Resources/Constraint	Components		Total Availability
	C_1	C_2	
Budget(Rs)	10 / unit	40 / unit	4000
Machine time	3 hr / unit	2 hr / unit	2000 hrs
Assembly time	2 hr / unit	3 hr / unit	1400 hrs
Profit	Rs.22	Rs. 40	

13. A firm can produce two types of cloth, say: A and B. Three kinds of wool are required for it, say : red, green and blue wool. One unit length of type A cloth needs 4 meters of red wool and 3 meters of green wool; whereas one unit length of type B cloth needs 3 meters of red wool, 2 meters of green wool and 5 meters of blue wool. The firm has only a stock of 10 meters of red wool, 6 meters of green wool and 15 meters of blue wool. It is assumed that the profit obtained from one unit length type A cloth is Rs. 13 and of type B cloth is Rs. 25. Formulate as LPP.

14. A company makes two type varieties, Alpha and Beta, of pens. Each Alpha pen needs twice as much labour time as a Beta pen. If only Beta pens are manufactured, the company can make 500 pens per day. The market can take only up to 150 alpha pens and 250 Beta pens per day. If alpha and Beta pens yield profits of Rs. 8 and Rs. 5 respectively per pen, determine the number of Alpha and Beta pens to be manufactured per day so as to maximize the profit. Formulate as L.P.P.

15. Graphical Method

Solve the following LLP by graphical method.

(1) Maximize $z = 25x_1 + 20x_2$

Subject to $16x_1 + 12x_2 \le 100$

$8x_1 + 16x_2 \le 80,$

$x_2 \ge 2,\ x_1, x_2 \ge 0.$

(2) Maximize $z = 3x_1 + 2x_2$

Subject to $-2x_1 + 3x_2 \le 9,$

$-x_1 + 5x_2 \le 20,$

$x_1, x_2 \ge 0.$

(3) Maximize $Z = 6x_1 + 8x_2$

Subject to $5x_1 + 10x_2 \le 60,$

$4x_1 + 4x_2 \le 40,$

$x_1,\ x_2 \ge 0.$

(4) Maximize $z = 5x_1 + 7x_2$

Subject to $x_1 + x_2 \le 4,$

$10x_1 + 7x_2 \le 35,$

$x_1, x_2 \ge 0.$

(5) Maximize $Z = 300x_1 + 400x_2$
Subject to $5x_1 + 2x_2 \le 180,$
$3x_1 + 3x_2 \le 135$
$x_1, x_2 \ge 0.$

(6) Max $Z = 40x_1 + 30x_2$
subject to $3x_1 + x_2 \le 30$
$x_1 \le 8$
$x_2 \le 12$
$x_1, x_2 \ge 0.$

(7) Maximize $Z = 3x_1 + 5x_2$
Subject to $x_1 + 2x_2 \le 20,$
$x_1 + x_2 \le 15,$
$x_2 \le 8,$
$x_1, x_2 \ge 0.$

(8) Maximize $z = 2x_1 + 3x_2$
Subject to $x_1 + x_2 \le 1,$
$3x_1 + x_2 \le 6,$
$x_1, x_2 \ge 0.$

Extra

16. State the different scope of operation research.
17. What are various phases of operation research?
18. What is model? List out the model.
19. Write the steps for solving Linear Programming Problem by Graphical method. State its limitations.
20. The ABC Company has been a producer of picture tubes for television sets and certain printed circuits for radios. The company has just explained 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 an AM-FM radio will require 3 hours. Each AM radio will contribute Rs. 40 to profits while an AM-FM radio will contribute Rs. 80 to profits. The marketing departments, after extensive research, have determined that a maximum of 15 AM radios and 10 AM-FM radios can be sold each week. Formulate the LPP.

21. Sudhakant has two iron mines. The production capacities of the mines are different. The iron ore can be classifies into good, mediocre and bad varieties after certain process. The owner has decided to supply 12 or more tons of good iron, 8 or more tons of mediocre iron and 24 or more tons of bad iron per week. The daily expense is Rs.2000 and that of the second mine is Rs.1600. The daily production of each type of iron is given in the table.

Mine	Daily production		
	Good	Mediocre	Bad
I	6	2	4
II	2	2	12

Formulate the LPP

22. Solve the following LP problems graphically

1) Minimize $Z = 3x_1 + 2x_2$
s.t. $5x_1 + x_2 \ge 10$
$x_1 + x_2 \ge 6$
$x_1 + 4x_2 \ge 12$
$x_1, x_2 \ge 0$

2) Maximize $Z = 30x_1 + 20x_2$
s.t. $3x_1 + 3x_2 \ge 40$
$3x_1 + x_2 \ge 40$
$2x_1 + 5x_2 \ge 44$
$x_1, x_2 \ge 0$

3) Max $z=3x_1+5x_2$
$x_1 + 2x_2 \le 2000$
$x_1 + 2x_2 \le 1500$
$x_2 \le 600$
$x_1, x_2 \ge 0$

23. A company produces two articles X and Y. These are two departments through which the articles are processed assembly and finishing. The potential capacity of the assembly department is 48 hours a week and that of the finishing department is 60 hours a week. Production of each of X requires 2 hours of assembly and 4 hours of finishing. Each unit of Y requires 4 hours in assembly and 2 hours in finishing department. If profit is Rs.6 for each unit of X and Rs.7 for each unit of Y, find out the number of units of X and Y to be produced each week to obtain maximum profit. (use graphical method).

UNIT 2

1. (1) Maximize $Z = 3x_1 + 5x_2$
Subject to $x_1 + x_2 \le 4, \quad 3x_1 + 2x_2 \le 18, \quad x_1, x_2 \ge 0$

2. (2) Maximize $Z = 7x_1 + 5x_2$
Subject to $x_1 + 2x_2 \le 6, \quad 4x_1 + 3x_2 \le 12, \quad x_1, x_2 \ge 0$

3. (3) Maximize $Z = 5x_1 + 7x_2$
Subject to $x_1 + x_2 \le 4, \quad 10x_1 + 7x_2 \le 35, \quad x_1, x_2 \ge 0$

4. (4) Maximize $Z = 3x_1 + 2x_2$
Subject to $2x_1 + x_2 \le 5, \quad x_1 + x_2 \le 3, \quad x_1, x_2 \ge 0$

5. (5) Maximize $Z = 3x_1 + 4x_2$
Subject to $x_1 + x_2 \le 6, \quad 2x_1 + 4x_2 \le 20, \quad x_1, x_2 \ge 0$

6. (6) Maximize $Z = 5x_1 + 3x_2$
Subject to $3x_1 + 5x_2 \le 15, \quad 5x_1 + 2x_2 \le 10, \quad x_1, x_2 \ge 0$

BIG M Method

7. (1) Maximize $Z = 3x_1 - x_2$
Subject to $2x_1 + x_2 \ge 2, \quad x_1 + 3x_2 \le 3, \quad x_1, x_2 \ge 0$

8. (2) Maximize $Z = 3x_1 - x_2 + 4x_3$
Subject to $-3x_1 + x_2 + x_3 \ge 2, \quad -5x_1 - 2x_2 \le 3, \quad x_1, x_2 \ge 0$

9. (3) Maximize $Z = 5x_1 - 2x_2 - x_3$
Subject to $2x_1 + 2x_2 - x_3 \ge 2, \quad 3x_1 - 4x_2 \ge 3, \ x_2 + 3x_3 \ge 5 \ where \quad x_1, x_2, x_3 \ge 0$

10. (4) Maximize $Z = -2x_1 - 9x_2 - x_3$
Subject to $x_1 + 4x_2 + 2x_3 \ge 5, \quad 3x_1 + x_2 + 2x_3 \ge 4, \quad x_1, x_2, x_3 \ge 0$

Extra

11. What is the standard form of the LPP? State its characteristics.
12. Write the steps of the algorithm for solving LPP by the Simplex method.
13. Explain about Big –M method for solving LPP by the Simplex method.
14. Max $z = 18x_1 + 24x_2$
s.t. $4x_1 + 2x_2 \le 8$, $2x_1 + 5x_2 \le 12$ where $x_1, x_2 \ge 0$

15. Min $Z = 12x_1 + 20x_2$
s.t. $6x_1 + 8x_2 \ge 10$, $7x_1 + 12x_2 \ge 12$ where $x_1, x_2 \ge 0$

16. Max $z = 30x_1 + 20x_2$
s.t. $3x_1 + x_2 \ge 40$, $2x_1 + 5x_2 \ge 44$ where $x_1, x_2 \ge 0$

UNIT 3

1. What is difference between transportation problem and assignment problem?
2. Give the algorithm of NWCM to obtain basic feasible initial solution to transportation problem.
3. Give the algorithm of LCM to obtain basic feasible initial solution to transportation problem.
4. Give the algorithm of VAM to obtain basic feasible initial solution to transportation problem.
5. Write the steps for solving a A.P. by Hungarian method.
6. Write a short note on travelling salesman problem.

7. **Examples of Transportation problem**

1)

	D_1	D_2	D_3	D_4	Supply
O_1	6	4	1	5	14
O_2	8	9	2	7	16
O_3	4	3	6	2	5
Dem.	6	10	15	4	

Obtain the initial solution to above TP using northwest corner method.

2)

	A	B	C	D	Supply
I	6	3	5	4	22
II	5	9	2	7	15
III	5	7	8	6	8
Demand	7	12	17	9	

Obtain the initial solution to above TP using least cost method.

3)

	D_1	D_2	D_3	D_4	Supply
O_1	1	2	3	4	6
O_2	4	3	2	0	8
O_3	0	2	2	1	10
Demand	4	6	8	6	

Obtain the initial solution to above TP using least cost method.

4)

	A	B	C	D	Supply
I	1	5	3	3	34
II	3	3	1	2	15
III	0	2	2	3	12
IV	2	7	2	4	19
Demand	21	25	17	17	

Obtain the initial solution to above TP using northwest corner method.

5)

	I	II	III	IV	Supply
A	21	16	15	13	11
B	17	18	14	23	13
C	32	27	18	41	19
Demand	6	10	12	15	

Obtain the initial solution to above TP using Vogel's approximation method.

6)

	D_1	D_2	D_3	D_4	Supply
O_1	1	2	1	4	30
O_2	3	3	2	1	50
O_3	4	2	5	9	20
Demand	20	40	30	10	

Obtain the initial solution to above TP using Vogel's approximation method.

7)

	I	II	III	IV	Supply
A	2	3	11	7	6
B	1	0	6	1	1
C	5	8	15	10	10
Demand	7	5	3	2	17

Obtain the optimal solution to above TP.

8)

	a	b	c	Supply
I	10	9	8	8
II	10	7	10	7
III	11	9	7	9
IV	12	14	10	4
Demand	10	10	8	

Obtain the initial solution to above TP using northwest corner method.

9)

	Warehouses				
	W_1	W_2	W_3	W_4	Supply
F_1	19	30	50	10	7
F_2	70	30	40	60	9
F_3	40	8	70	20	18
Demand	5	8	7	14	

Obtain the optimal solution to above TP.

10)

	Destination				Supply
Source	I	II	III	IV	
A	19	14	23	11	11
B	15	16	12	21	13
C	30	25	16	39	19
Demand	6	10	12	15	

Obtain the optimal solution to above TP.

8. Examples of Assignment problem

Solve the following Assignment Problems.

1)

	P	Q	R	S
A	22	30	21	15
B	18	33	9	31
C	44	25	24	21
D	23	30	28	14

2)

	I	II	III	IV
1	11	10	18	5
2	14	13	12	19
3	5	3	4	2
4	15	18	17	9

3)

	A	B	C	D	E	F
1	13	13	16	23	19	9
2	11	19	26	16	17	18
3	12	11	4	9	6	10
4	7	15	9	14	14	13
5	9	13	12	8	14	11

4)

	P	Q	R	S
A	5	3	4	7
B	2	3	7	6
C	4	1	5	2
D	6	8	1	2

5) Find the assignment of salesmen to various districts which will result minimum cost.

Salesman	District			
	1	2	3	4
A	16	10	14	11
B	14	11	15	15
C	15	15	13	12
D	13	12	14	15

6) Solve the following assignment problem so as to minimize the time (in days) required to complete all the task.

person	task				
	1	2	3	4	5
A	6	5	8	11	16
B	1	13	16	1	10
C	16	11	8	8	8
D	9	14	12	10	16

7) A department has 5 employees and five jobs are to be performed. The time each man will take to perform each job is given in the following table below. How should the job be allocated one per employee, so as to minimize the total man-hours.

Cost matrix

Jobs	Employee				
	A	B	C	D	E
1	9	3	10	13	4
2	9	17	13	20	5
3	5	14	8	11	6
4	11	13	9	12	3
5	12	8	14	16	7

Extra

9. Three fertilizers factories X, Y and Z located at different places of the country produce 6,4 and 5 lakh tones of urea respectively. Under the directive of the central government, they are to be distributed to 3 States A, B and C as 5, 3 and 7 lakh respectively. The transportation cost per tones in rupees is given below:

	A	B	C
X	11	17	16
Y	15	12	14
Z	20	12	15

Find out suitable transportation pattern at minimum cost by North West Corner method and Least Cost method.

10. Determine an IBFS by Vogel's Approximation method.

Source	D1	D2	D3	D4	Supply
S1	19	30	50	10	7
S2	70	30	40	60	9
S3	40	8	70	20	18
Demand	5	8	7	14	

11. A departmental has five employees with five jobs to be performed. The time (in hours) each men will take to perform each job is given in the effectiveness matrix.
How the jobs should be allocated, one per employee, so as to minimize the total man-hours.

	Employees				
jobs	1	2	3	4	5
a	10	5	13	15	16
b	3	9	18	13	6
c	10	7	2	2	2
d	7	11	9	7	12
e	7	9	10	4	12

12. A machine operator processes five types of items on his machine each week, and must choose a sequence for them. The set up cost per change depends on the item presently on the machine and the set- up cost be made according to the following table:

	To item				
From item	A	B	C	D	E
1	--	4	7	3	4
2	4	--	6	3	4
3	7	6	--	7	5
4	3	3	7	--	7
5	4	4	5	7	--

If he processes each type of item once and only once each week, how should he sequence the items on his machine in order to minimize the total set-up cost?

13. A city corporation has decided to carry out road repairs on main four arteries of the city. The government has agreed to make a special grant of Rs 50 lakh towards the cost with a condition that repairs are done at the lowest cost and quickest time. If the conditions warrant, a supplementary token grant will also be considered favorably. The corporation has floated tenders and five contractors have sent in their bids. In order to expedite work, one road will be awarded to only one contractor.

Cost of Repairs (Rs in lakh)

Contractors	R_1	R_2	R_3	R_4	R_5
C_1	9	14	19	15	13
C_2	7	17	20	19	18
C_3	9	18	21	18	17
C_4	10	12	18	19	18
C_5	10	15	21	16	15

Find the best way of assigning the repair work to the contractors and the costs.
If it is necessary to seek supplementary grants, what should be the amount sought?

14. A company has factories at F1, F2 & F3 which supply warehouses ay W1,W2 and W3. Weekly factory capacities are 200,160 and 90 units respectively. Weekly warehouses requirements are 180,120 and 150 units respectively. Unit shipping costs (in rupees) are as follows:

	Warehouse			
Factory	w1	w2	w3	Supply
F1	16	20	12	200
F2	14	8	18	160
F3	26	24	16	90
Demand	180	120	150	

Determine the optimum distribution for this company to minimize the shipping cost.

15. Determine the optimum basic feasible solution to the following transportation problem.

	A	B	C	Available
I	50	30	220	1
II	90	45	170	3
III	250	200	50	4
Required	4	2	2	

Hint: Find Initial Basic Feasible Solution using VAM method.

16. Determine the optimum basic feasible solution to the following transportation problem.

	D_1	D_2	D_3	D_4	Available
O_1	1	2	1	4	30
O_2	3	3	2	1	50
O_3	4	2	5	9	20
Required	20	40	30	10	100

Hint: Find Initial Basic Feasible Solution using Lowest cost method.

17. Determine the optimum basic feasible solution to the following transportation problem in which cell entries represent unit costs.

		To		Available
	2	7	4	5
From	3	3	1	8
	5	4	7	7
	1	6	2	14
Required	7	9	18	34

Hint: Find Initial Basic Feasible Solution using VAM.

18. Solve the transportation problem where all entries are unit costs.

	D_1	D_2	D_3	D_4	D_5	a_i
O_1	73	40	9	79	20	8
O_2	62	93	96	8	13	7
O_3	96	65	80	50	65	9
O_4	57	58	29	12	87	3
O_5	56	23	87	18	12	5
b_j	6	8	10	4	4	

Hint: Find Initial Basic Feasible Solution using Lowest cost method.

19. The following table gives the cost for transporting material from supply points A, B, C and to demand points E, F, G, H and J.

				To		
		E	F	G	H	J
	A	8	10	12	17	15
	B	15	13	18	11	9
From	C	14	20	6	10	13
	D	13	19	7	5	12

The present allocation is as follows:
A to E 90, A to F 10, B to F 150, C to F 10, C to G 50, C to J 120, D to H 210, D to J 70.
Check if this allocation is optimum. If not, find an optimum schedule.

20. The following table shows all the necessary information on the available supply to each warehouse, the requirement of each market and the unit transportation cost for each warehouse to each market.

	Market				
	I	II	III	IV	Supply
A	5	2	4	3	22
Warehouse B	4	8	1	6	15
C	4	6	7	5	8
Requirement	7	12	17	9	

The shipping clerk has worked out the following schedule from experience: 12 units from A to II, 1 unit from A to III, 9 units from A to IV, 15 units from B to III, 7 units from C to I and 1 unit from C to III.
Check and see if the clerk has the optimum schedule. If not, find the optimum schedule and minimum total shipping cost.

21. Determine the optimum basic feasible solution to the following transportation problem.

	A	B	C	Available
I	50	30	220	1
II	90	45	170	3
III	250	200	50	4
Required	4	2	2	

Hint: Find Initial Basic Feasible Solution using Lowest cost method.

22. Is $x_{13} = 50$, $x_{14} = 20$, $x_{21} = 55$, $x_{31} = 30$, $x_{32} = 35$, $x_{34} = 25$ an optimum solution of the following transportation problem?

			To		Available
From	6	1	9	3	70
	11	5	2	8	55
	10	12	4	7	90
Required	85	35	50	45	

23. Solve following assignment problem.

	1	2	3	4
I	12	30	21	15
II	18	33	9	31
III	44	25	24	21
IV	23	30	28	14

24. Solve following cost minimizing problem.

		Jobs				
		I	II	III	IV	V
Machines	A	45	30	65	40	55
	B	50	30	25	60	30
	C	25	20	15	20	40
	D	35	25	30	30	20
	E	80	60	60	70	50

25. Solve following cost minimizing problem.

		Jobs				
		I	II	III	IV	V
Machines	A	2	9	2	7	1
	B	6	8	7	6	1
	C	4	6	5	3	1
	D	4	2	7	3	1
	E	5	3	9	5	1

26. A department head has four subordinates and four tasks have to be performed. Subordinates differ in efficiency and tasks differ in their intrinsic difficulty. Time each man would take to perform each task is given in the efficiency matrix. How the tasks should be allocated to each person so as to minimize the total man-hours?

		I	II	III	IV
Tasks	A	8	26	17	11
	B	13	28	4	26
	C	38	19	18	15
	D	19	26	24	10

27. A car hire company has one car at each of five depots a, b, c, d and e. A customer requires a car in each town, namely A, B, C, D and E. Distance (in kms) between depots (origins) and towns 9destinations) are given in the following matrix:

	a	b	c	d	e
A	160	130	175	190	200
B	135	120	130	160	175
C	140	110	155	170	185
D	50	50	80	80	110
E	55	35	70	80	105

How should cars be assigned to customers so as to minimize the distance travelled?

28. A department has five employees with five jobs to be performed. The time (in hours) each man will take to perform each job is given in the effectiveness matrix.

		Employees				
		I	II	III	IV	V
Jobs	A	10	5	13	15	16
	B	3	9	18	13	6
	C	10	7	2	2	2
	D	7	11	9	7	12
	E	7	9	10	4	12

How should the jobs be allocated, one per employee, so as to minimize the total man-hours?

29. A solicitor's firm employs typists for their daily work. There are five typists and their charges are different. Only one job is given to one typist. Find least cost allocation for the following data:

		Jobs				
		P	Q	R	S	T
Typists	A	85	75	65	125	75
	B	90	78	66	132	78
	C	75	66	57	114	69
	D	80	72	60	120	72
	E	76	64	56	112	68

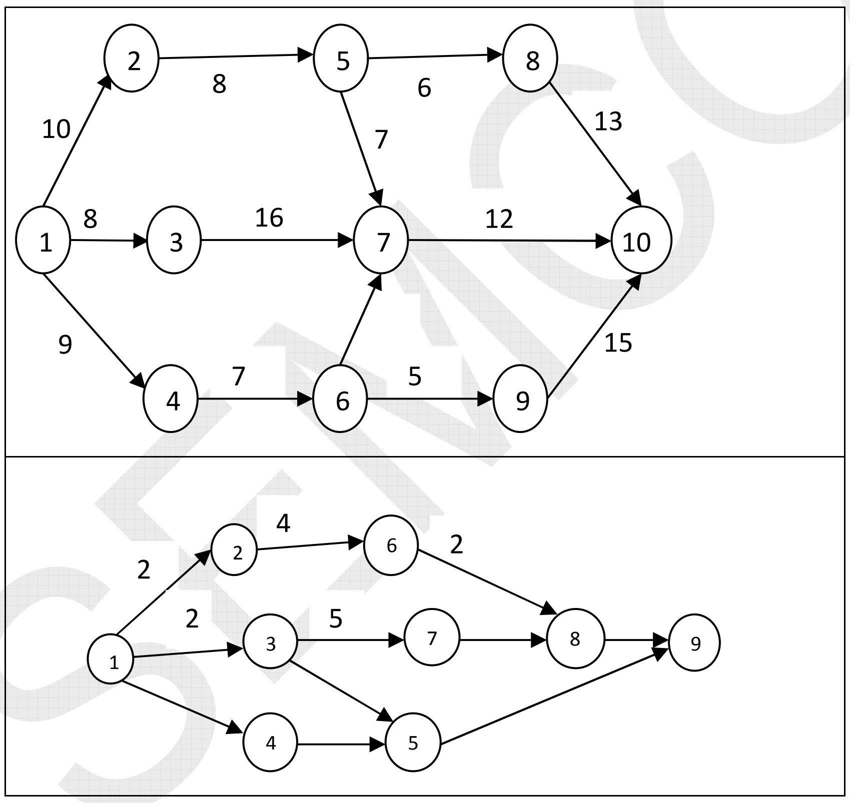
30. In a textile sales emporium, four salesman A, B, C and D are available to four counters W, X, Y and Z. Each salesman can handle any counter. The service (in hour) of each counter when manned by each salesman is given below:

		Salesman			
		A	B	C	D
Counter	W	41	72	39	52
	X	22	29	49	65
	Y	27	39	60	51
	Z	45	50	48	52

How should the salesman be allocated appropriate counters so as to minimize the service time? Each salesman must handle only one counter.

UNIT 4

1. Write down the procedure for solving problem of sequencing with two machines.
2. State the rules for drawing network diagram.
3. Write down the procedure to obtain optimum completion time using Critical Path method.
4. Find the critical path and calculate the Total float and Free float for the following PERT diagram.



5. A small maintenance project consists of the following 12 jobs

Jobs	Duration in days	Jobs	Duration in days	Jobs	Duration in days
1-2	2	3-5	5	6-10	4
2-3	7	4-6	3	7-9	4
2-4	3	5-8	5	8-9	1
3-4	3	6-7	8	9-10	7

Draw the arrow network of the project. Determine the critical path.

6. A project has the following time schedule:

Activity	Time In month	Activity	Time In month	Activity	Time In month
1-2	2	3-6	8	6-9	5
1-3	2	3-7	5	7-8	4
1-4	1	4-6	3	7-9	3
2-5	4	5-8	1		

Construct PERT network and compute total float for each activity. Find Critical path with its duration.

7. In a machine shop 8 different products are being manufactured each requiring time on two different machines A and B are given in the table below:

Product	1	2	3	4	5	6	7	8
Machine-A	30	45	15	20	80	120	65	10
Machine B	20	30	50	35	35	40	50	20

Find an optimal sequence of processing of different product in order to minimize the total manufctured time for all product. Find total ideal time for two machines and elapsed time.

8. In a machine shop 6 different products are being manufactured each requiring time on two different machines A and B are given in the table below:

Product	1	2	3	4	5	6
Machine-A	30	120	50	20	90	110
Machine B	80	100	90	60	30	80

Find an optimal sequence of processing of different product in order to minimize the total manufctured time for all product. Find total ideal time for two machines and elapsed time.

9. In a printing shop 7 different books are printed and bounded on two different machines A and B. Time required on two machines are given in the table below:

Product	1	2	3	4	5	6	7
Printing	3	4	8	3	6	7	5
Binding	8	6	3	7	2	8	4

Find an optimal sequence of processing of different product in order to minimize the total manufctured time for all product. Find total ideal time for two machines and elapsed time.

<u>Extra</u>

10. Write similarities and differences between PERT and CPM.
11. Write applications of PERT/CPM techniques.
12. Write uses of PERT/CPM techniques.
13. Write the steps for Processing n jobs through two machines.
14. State “the Principle of Optimality” and its mathematical formulation of a dynamic programming problem.

15. Draw the Network Diagram for the following activities and find the critical path.

Job	A	B	C	D	E	F	G	H	I	J	K
Job time(days)	13	8	10	9	11	10	8	6	7	14	18
Immediate predecessors	-	A	B	C	B	E	D,F	E	H	G,I	J

16. A project has the following time Schedule. Construct a PERT network and compute Critical Path and its duration. Also calculate Total float,Free float.

Activity	1-2	1-3	2-4	3-4	3-5	4-9	5-6
Time in Weeks	4	1	1	1	6	5	4
Activity	5-7	6-8	7-8	8-9	8-10	9-10	
Time in Weeks	8	1	2	1	8	7	

17. A project schedule has the following characteristics. Construct the PERT network and find the critical path and time duration of the project.

Activity	1 - 2	1 - 4	1 - 7	2 - 3	3 - 6	4 - 5	4 - 8	5 - 6	6 - 9	7 - 8	8 - 9
Time	2	2	1	4	1	5	8	4	3	3	5

18. A salesman located in a city A decided to travel to city B. He knew the distance of alternative routes from city A to city B. He then drew a highway network map as shown in Figure. The city of origin, A, is city 1. The destination city B, is city 10. Other cities through which the salesman will have to pass through are numbered 2 to 9. The arrow representing routes between cities and distances in kilometers are indicated on each route. The salesman's problem is to find the shortest route that covers all the selected cities from A to B.

Also the distance in kilometers is given below:

Activity	Distance travelled.	Activity	Distance travelled.
1-2	4	3-7	4
1-3	6	4-5	6
1-4	3	4-6	10
2-5	7	4-7	5
2-6	10	5-8	4
2-7	5	5-9	8
3-5	3	6-8	3
3-6	8	6-9	7
3-7	4	7-8	8
4-5	6	7-9	4
4-6	10	8-10	7
4-7	5	9-10	9