



**Subject Name: Operations Research (OR)**

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**Year and Sem, Department: IV/I, Mechanical Engineering.**

**Unit-I: Introduction to OR. Phases & models & applications in OR. Linear programming problem. solving LPP by Graphical method & Simplex method.**

**Important points / Definitions:**

1. Introduction to OR
2. Definition of Operations Research
3. Phases in OR
4. Models in OR
5. General Applications of OR
6. Introduction to LPP
7. Formulation of LPP
8. Graphical method of solving a LPP.
9. Simplex method of solving an LPP
10. Normal simplex method, Two-phase simplex method & BIG-M Simplex method

**Short Questions :**

1. What is operations research? (Nov 2016)
2. Give various definitions of operations research? (Nov 2016)
3. What is meant by Redundant constraint ? (Mar 2017)
4. What are the shadow prices & what is its significance in solving (Mar 2017)
5. What is a model & List out the various classification schemes of Operations Research Models.( Nov 2017)
6. Explain the History of OR (Mar 2015)
7. Define slack & surplus variables (Nov/Dec 2015)
8. Write the phases in OR (Nov /Dec 2018)
9. Write short notes on Artificial variable techniques( Nov/Dec 2018)
10. Define Linear programming problem.

**Long Questions**

1. What is a simplex? Describe simplex method of solving linear programming problem. (Nov 2017 )



2. Use Simplex method to solve

Minimize  $Z = x_2 - 3x_3 + 2x_5$   
subject to constraints:  $3x_2 - x_3 + 2x_5 \leq 7$ ,  
 $-2x_2 + 4x_3 \leq 12$   
 $-4x_2 + 3x_3 + 8x_5 \leq 10$ ;  
 $x_2 \geq 0, x_3 \geq 0, x_5 \geq 0$  (Nov 2016)

3. Write the Algorithm for Simplex method.(Mar 2015)

4. Explain in detail the applications & Limitations of LPP. ( Nov/Dec 2015)

5. Explain the assumptions in LPP

6. Solve the following LPP

Maximize  $Z = 15X_1 + 6X_2 + 9X_3 + 2X_4$   
Subject to constraints  $2X_1 + X_2 + 5X_3 + 6X_4 \leq 20$ ,  
 $3X_1 + X_2 + 3X_3 + 25X_4 \leq 20$ ,  
 $7X_1 + X_4 \leq 70$

**Fill in the Blanks / Choose the Best:**

1. “Art of winning the war without involving in the war “ is termed as

A) Hungarian method B) Simplex method C) OR D)None ( )

2. Graphical method cannot be applied to an LPP with

A) More than 2 variables B) less than C) Exactly two D)None ( )

3. Simplex method was developed by

A) Hungarian B) Dantzig C) Poisson D)None ( )

4. A non negative variable which is being added to the left side of the constraint in order to convert it into equation is termed as

A)surplus variable B) Slack variable C) Alpha D)None ( )

5. In Big M method, M denotes

A) profit B) Loss C) Penalty D)None ( )

6. Simplex method is used for \_\_\_\_\_

7. Surplus variable is used for \_\_\_\_\_

8. In an LPP right side parameters are denoted by \_\_\_\_\_

9. Artificial variable is denoted by \_\_\_\_\_

10. Minimum ratio is indicated by \_\_\_\_\_



**Unit-II: Assignment problem & models in Ap. Travelling sales man problem. Transportation problem .IBFS & Optimal solution**

**Important points / Definitions:**

- 1. Introduction to Assignment problem. Models in AP**
- 2. Unbalanced AP**
- 3. Maximal & Restricted AP**
- 4. Travelling sales man problem & basics.**
- 5. solution to TSP**
- 6. Transportation problem & basics**
- 7. IBFS Methods**
- 8. Optimal solution**

**Short Questions :**

1. How the assignment problem can be viewed as a linear programming problem? (Nov 2017)
2. Explain the steps in transportation algorithm. (Nov 2017)
3. Formulate the travelling – Salesman problem as an assignment problem (Nov 2017)
4. What is meant by Optimal solution? ( Nov/Dec 2016)
5. Distinguish between Assignment problem & allocation problem.(Mar 2017)
6. Define Unbalanced Transportation problem.
7. Define Travelling sales man problem.
8. Write the Algorithm for Vogels approximation method.

**Long Questions**

1. What is the unbalanced Assignment problem? How is it solved by the Hungarian method? (Nov/Dec 2016)
2. Find the optimal solution for the assignment problem with the following cost matrix. (Nov 2017)

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



- 3. What is an Unbalanced Assignment problem & How it is solved by Hungarian method (Nov/Dec 2016)
  
- 4. There are three sources or origins which store a given product. These sources supply these products to four dealers. The capacities of the sources ( $S_i$ ) and the demands at dealers ( $D_j$ ) are as given below.

$$S_1 = 150, S_2 = 40, S_3 = 80$$

$$D_1 = 90, D_2 = 70, D_3 = 50, D_4 = 60.$$

The cost of transporting the product from various sources to various dealers is shown in the table below.

|                | D <sub>1</sub> | D <sub>2</sub> | D <sub>3</sub> | D  |
|----------------|----------------|----------------|----------------|----|
| S <sub>1</sub> | 27             | 23             | 31             | 60 |
| S <sub>2</sub> | 10             | 45             | 40             | 30 |
| S <sub>3</sub> | 30             | 54             | 35             | 50 |

Find out the optimum solution for transporting the products at a minimum cost. (Nov /Dec 2017)

- 5. Write the Algorithm for Modi method.( Nov/Dec 2015)
  
- 6. Explain the various types of Travelling sales man problems.
  
- 7. Find the IBFS for the following Transportation problem. (March 2018)

|    | D1 | D2 | D3 | D4 |
|----|----|----|----|----|
| O1 | 19 | 30 | 50 | 10 |
| O2 | 70 | 30 | 40 | 60 |
| O3 | 40 | 8  | 70 | 20 |

- 8. Write the Algorithm for North west corner rule.



**Fill in the Blanks / Choose the Best:**

1. Hungarian method is used for solving  
A) TSP      B) AP      C) TP      D) None
2. In an Assignment problem if number of rows are not equal to number of columns then it is A) Hungarian method B) Unbalanced AP C) Degeneracy in TP D) None ( )
3. If  $N=m+n-1$ , then the IBFS is A) Degenerate IBFS B) Non-degenerate C) TTC D) None ( )
4. If the total sum of the available quantities is not equal to the total sum of the required quantities, then such a TP is called A) AP B) Unbalanced TP C) TSP D) None
5. In Travelling sales man problem,  $X_{ij}$  denotes A) TSP B) AP C) Quantity D) None
6. In general if there are  $n$  cities then the number of routes will be \_\_\_\_\_
7. The method used for finding the Optimal solution is \_\_\_\_\_
8. VAM stands for \_\_\_\_\_
9. MODI stands for \_\_\_\_\_
10. Every TSP is a by default \_\_\_\_\_ problem.

**Unit-III: Job sequencing problem & Replacement models**

**Important points/Definitions**

1. Job sequencing problem & Terminology.
2. Jhonson's Algorithm
3.  $n$ - job,2-machine problems &  $n$ -job,3-machine problem.
4.  $n$ -job, $m$ -machine problem
- 5.

**Short Questions :**

1. Define the problem of Job sequencing.(Nov 2017)
2. What are the conditions recommended for replacing the machine with a new one when you already have an old one.( Mar 2017)



3. What are the situations which make the replacement of items necessary?(Nov 2017)
4. What are the assumptions made in the sequencing problem?( Nov 2016)
5. What is priority sequencing and what are the priority sequencing rules?( Nov 2016)
6. What is the need for a replacement?
7. Define optimal replacement.

**Long Questions**

1. A truck owner finds from his past records that the maintenance cost per year of a truck whose purchase price is Rs.8000, are given below:

|                        |   |      |      |      |      |      |      |      |      |
|------------------------|---|------|------|------|------|------|------|------|------|
| Year                   | : | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    |
| Maintenance cost (Rs): |   | 1000 | 1300 | 1700 | 2200 | 2900 | 3800 | 4800 | 6000 |
| Resale Price           | : | 4000 | 2000 | 1200 | 600  | 500  | 400  | 400  | 400  |

(Nov

Determine at what time it is profitable to replace the truck? 2017)

2. Find the sequence that minimizes the total time required in performing the following jobs on three machines in the order A-B-C as shown in the below table. Also find the total elapsed time.(Nov 2016)

| Machine/Job | 1 | 2 | 3 | 4 | 5  | 6 |
|-------------|---|---|---|---|----|---|
| <b>A</b>    | 8 | 3 | 7 | 2 | 5  | 1 |
| <b>B</b>    | 3 | 4 | 5 | 2 | 1  | 6 |
| <b>C</b>    | 8 | 7 | 6 | 9 | 10 | 9 |

4. Write the Jhonson’s Algorithm in detail.(Nov 2015)
5. Explain the procedure of converting three machine problem to 2 machine problem.(Nov 2014)
6. Explain Individual & Group replacement policies.

**Fill in the Blanks / Choose the Best:**

1. Jhonson’s algorithm can be readily applied for

- A) 4-machine problem B) 2-machine problem C) M D) None ( )

2. In Job sequencing problem, T stands for

- A) slow time B) Total elapsed time C) Free time D) None ( )

3.The replacement problems are useful when need for replacement arises due to

- A) Decreased efficiency B) Failure C) Break down D) None ( )



4. Salvage value is also known as

- A) Scrap value B) Resale value C) Total value D) None ( )

5. The job sequencing problem is used for

- A) Minimizing total cost B) Ascertaining total idle time C)

Ascertaining total elapsed time D) None ( )

6. The time in which no processing of jobs is done on the machines during the total elapsed time is \_\_\_\_\_

7. In processing  $n$  jobs through  $m$  machines \_\_\_\_\_ are created.

8. Average total annual cost is \_\_\_\_\_

9. In \_\_\_\_\_ situation receiving money today is more valuable than receiving it in future.

10. Under \_\_\_\_\_ failure, probability of failure increases with the increase in the life of an item.

**Unit-IV: Game theory, pure games & mixed games. Inventory concepts. EOQ & problems on EOQ.**

**Important points / Definitions:**

- 1. Introduction to Game theory & Basics**
- 2. Pure strategy games**
- 3. Mixed strategy games**
- 4. Introduction to Inventory.**
- 5. Various methods in Inventory**
- 6. Concept of EOQ**
- 7. Problems on EOQ**

**Short Questions**

1. Explain the terms i) Pure strategy ii) Mixed strategy. ( Nov 2016)
2. What are the characteristics of Game theory. (Nov 2017)
3. Which competitive situation is called as a Game (March 2017)



4. What is Inventory Management & Write the major decisions concerning Inventory.
5. What are the consequences of over Inventory & under Inventory situations? (Mar 2017)
6. What are the different types of inventory models?
7. Discuss a mixed strategy.
8. What is the necessity of maintaining inventory?

Long type Questions

1. A stockiest has to supply 400 units of a product every Monday to his customers. He gets the product at Rs.50 per unit from the manufacturer. The cost of ordering and transportation from the manufacturer is Rs.75 per order. The cost of carrying inventory is 7.5% per year of the cost of the product. Find (a) the economic lot size (b) the total optimal cost. (Nov 2016)
2. Solve the following Game. The player A is represented row wise & player B column wise. (Nov 2017)

|     | I  | II | III | IV | V  |
|-----|----|----|-----|----|----|
| I   | -2 | 0  | 0   | 5  | 3  |
| II  | 3  | 2  | 1   | 2  | 2  |
| III | -4 | -3 | 0   | -2 | 6  |
| IV  | 5  | 3  | -4  | 2  | -6 |

3. Explain in detail about the concept of Principal of Dominance.
4. Explain the procedure for Graphical method





5. Obtain the optimal strategies for both persons and the value of the game for zero-sum two-person game whose payoff matrix is given below:( Nov 2016)

|   |   |   |   |
|---|---|---|---|
| 3 | 2 | 4 | 0 |
| 2 | 4 | 4 | 2 |
| 4 | 2 | 4 | 0 |
| 0 | 4 | 0 | 8 |

6. What do you mean by Economic order quantity [ EOQ] & Explain the concept of EOQ.
7. Explain the various Inventory costs involved in the various Inventory problems along with examples.
8. Explain in detail about the Analytical methods.

**Fill in the Blanks / Choose the Best:**

1. A quantitative measure of satisfaction a person gets at the end of each play is called as \_\_\_\_\_
2. \_\_\_\_\_analysis attempts to classify Inventory items on the basis of their usage in monetary terms.
3. ROI stands for \_\_\_\_\_
4.  $2 \times n$  &  $m \times 2$  are solved by a new methodology called as \_\_\_\_\_ methods.
5. The semi finished items accumulated at different stages of manufacturing are known as \_\_\_\_\_ Inventory.



6. \_\_\_\_\_ is used to reduce the size of the matrix.

- A) Principle of saddle B) principle of maximum C) Principle of Dominance D) None ( )

7. \_\_\_\_\_ is a decision analysis tool which summarizes pros & cons of a decision in tabular form

- A) pure strategy B) Mixed strategy C) pay off matrix D) Optimal strategy

8. Cricket is a \_\_\_\_\_ person Game

- A) 12 B) 11 C) 13 D) None ( )

9. All the costs associated with placing an order for purchase of items is

- A) set up cost B) carrying cost C) Ordering cost D) None ( )

10. Arithmetic method is a

- A) small game B) analytical method C) pure game D) None ( )



**Unit-V: Concept of queuing theory. Basics & models in queuing theory, Bellman's principle & Dynamic programming problem. Concept of Simulation. Advantages, disadvantages applications.**

**Important points / Definitions:**

- 1. Introduction to Queuing theory & Basics**
- 2. Models in Queuing theory.**
- 3. Dynamic programming**
- 4. Bellman's Principle**
- 5. concept of Simulation**
- 6. Applications of simulation**
- 7. Advantages & Disadvantages in Simulation**

**I. Short Questions**

- 1. Define Bellman's principle of Optimality with examples. (Mar 2017)**
- 2. What is simulation? (Nov 2016)**
- 3. What are the major limitations of simulation. (Nov 2017)**
- 4. What do you understand by (M/M/1) : ( $\alpha$ /FCFS) (Mar 2017)**
- 5. What are the various elements of the Queue. (Nov 2016)**
- 6. What do you understand by a Queue? Give some important applications of Queuing theory.**
- 7. Write the general applications of Simulation.**
- 8. Define Dynamic programming.**

**Long Answer Questions**

- 1. a) State the Bellman's Principle of Optimality.  
b) What are the applications of dynamic programming?  
[Nov 2016]**
- 2. A supermarket has two girls ringing up sales at the counters. If the service time for each customer is exponential with mean 4 minutes, and if people arrive in a Poisson fashion at the counter at the rate of 10 per hour, then calculate:  
a) The probability of having to wait for service;  
b) The expected percentage of idle time for each girl;  
c) If a customer has to wait, find the expected length of his waiting time. (Nov 2017)**
- 3. Jobs arrival at a workstation in a manufacturing plant is in a Poisson fashion at an average rate of five per hour. The time to machine one job is an exponential distribution with a mean time of 20 minutes. What is the expected time a job has to wait at the workstation? What will be the average number of jobs waiting at the workstation at any time? What is the probability that there will be more than four jobs? (Nov 2016)**
- 4. Define simulation. Why is simulation used? Give one application area where this technique is used in practice? [Nov 2017]**



5. Explain the application of Queuing systems?
6. Discuss dynamic programming with suitable examples?
7. Discuss the advantages and disadvantages of simulation.
8. Discuss types of simulations?

**Fill in the Blanks / Choose the Best:**

1. FIFO stands for \_\_\_\_\_
2. Mean arrival rate is denoted by \_\_\_\_\_
3. \_\_\_\_\_ refers to the order in which the members of the queue are selected for service.
4. Dynamic programming problems are solved recursively by using \_\_\_\_\_ approach.
5. A model which resembles like a real time model and which reacts like a real time model is called as \_\_\_\_\_
6. One of the operating characteristics of queues is
7. A) Queue length B) Queue line C) Queuing width D) Queue breadth
8. Dynamic programming was proposed by A) Richard Bellman B) Poisson C) Dantzig D) None
9. Different forms OF Simulation are A) Queue length B) Queue line C) Queuing width D) Queue breadth
10. Dynamic programming is applicable to A) Cargo problem B) capital budgeting C) Resource allocation D) None