TECHNOCRATS INSTITUTE OF TECHNOLOGY-MBA

By AICTE New Delhi & Govt. of Madhya Pradesh

Affiliated To Barkatullah University, Bhopal

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REFERENCES

1. Operations Research: An Introduction
   Author: Hamdy A. Taha
   Publisher: Pearson Education
   Description: A comprehensive book covering fundamentals, mathematical models, linear programming, and advanced O.R. techniques.

2. Introduction to Operations Research
   Authors: Frederick S. Hillier and Gerald J. Lieberman
   Publisher: McGraw Hill Education
   Description: A classic text emphasizing problem-solving, model building, and practical applications of O.R.

3. Operations Research: Principles and Practice
   Authors: A. Ravindran, Don T. Phillips, and James J. Solberg
   Publisher: Wiley India
   Description: Focuses on modeling, computational methods, and managerial applications of O.R.

4. Operations Research: Theory and Applications
   Author: J.K. Sharma
   Publisher: Macmillan India
   Description: Popular among Indian universities, provides simple explanations, illustrations, and solved problems for MBA students.

5. Operations Research
   Author: Kanti Swarup, P.K. Gupta, and Man Mohan
   Publisher: Sultan Chand & Sons
   Description: Detailed book with extensive numerical examples, suitable for both beginners and advanced learners.

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UNIT 1: Introduction: Meaning of O.R., Modeling in operation research, Principle of modeling.

UNIT 2: Introduction to linear programming, Problem formulation, Characteristics, assumptions and applications, graphical solution of two variable problem, linear programming in standard form. Special cases: Infeasibility, Unbounded, Alternative Optima, Degeneracy, Duality and Sensitivity Analysis.

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UNIT 1: Introduction to Operations Research (O.R.)

Meaning of Operations Research

Operations Research (O.R.) is a branch of applied mathematics and analytics that focuses on the use of advanced analytical methods, such as mathematical modeling, statistical analysis, and mathematical optimization, to aid decision-making and improve efficiency within organizations. O.R. aims to find optimal or near-optimal solutions to complex decision-making problems, frequently involving maximizing or minimizing objectives (profit, performance, yield, or minimizing loss, risk, or cost). The discipline originated in military operations before World War II and has expanded across industries like logistics, production, services, and finance.

Key Features of O.R.

- **Utilizes scientific and mathematical techniques.**
- **Focuses on optimization and efficiency.**
- **Applies to real-world problems involving resources, constraints, and objectives.Modeling in Operations Research**

Modeling is the process of creating a representative mathematical or logical structure of a real-world decision problem for analysis and solution. The goal is to abstract essential elements and relationships, formulate them into mathematical representations, and analyze the effects of different actions and policies. Modeling can deal with both existing systems and anticipated situations.

Steps in Modeling

- **Define the problem.**
- **Collect relevant data.**
- **Construct a model that represents the problem.**
- **Derive and test a solution.**
- **Validate the model and implement the solution.**

Importance of Modeling

- **Identifies alternatives and outcomes.**
- **Provides a structured framework for complex problems.**

- **Allows for experimentation with different scenarios.Principle of Modeling**

The proper modeling methodology is guided by several core principles that ensure the usefulness and accuracy of the model in representing a real-world situation:Simplicity: If a simple model is adequate, prefer it over complexity.

- **Practicality: Models are tools for decision-makers, not replacements.**
- **Validation: Test and validate before implementation to ensure accuracy.**
- **Suitability: Avoid forcing problems to fit a technique. Choose the right modeling approach for the problem, not vice versa.**
- **Information Quality: The model is only as good as the data it uses.**

UNIT 2: Linear Programming

Introduction to Linear Programming

Linear Programming (LP) is a mathematical technique used for optimizing (maximizing or minimizing) a linear objective function, subject to a set of linear equality or inequality constraints. It is widely applied in areas like resource allocation, production scheduling, transportation, workforce planning, and more.

Core Elements of Linear Programming

- **Decision Variables: Unknown quantities to be determined (e.g., how many units to produce).**
- **Objective Function: The function to be optimized (e.g., profit or cost).**
- **Constraints: Limitations or requirements (e.g., resource availability, minimum production).**
- **Non-negativity Restrictions: Decision variables usually cannot take negative values.**

Problem Formulation

Formulating an LP problem involves translating a real-world scenario into a mathematical format. The steps include:Identify decision variables (x_1,x_2,…).

1. **State the objective function (maximize profit or minimize cost).**
2. **Define the constraints as linear inequalities or equations.**
3. **Incorporate non-negativity constraints ($x_i \geq 0$).**

Example

A company produces two products (A and B). Let x_1= units of A to produce, x_2 = units of B. Objective: maximize profit.

- **Objective Function: Maximize $Z = 20x_1 + 30x_2$.**
- **Constraints:**
    - **Labor: $3x_1 + 4x_2 \leq 240$**
    - **Material: $x_1 + 2x_2 \leq 100$**
    - $x_1, x_2 \geq 0$

Characteristics, Assumptions, and Applications

Characteristics

- **All relationships (objective and constraints) are linear.**
- **There are limited resources or boundaries (constraints).**
- **Objective is either maximization or minimization.**

Assumptions of Linear Programming

1. **Proportionality (Linearity): Contributions are linear—doubling a variable doubles its effect on the objective and constraints.**
2. **Additivity: The impact of variables is additive, with no interaction terms**
3. **Divisibility: Variables can take any non-negative values, including fractions (not required to be integers).**
4. **Certainty: Parameters (coefficients in objective and constraints) are precisely known and constant.**
5. **Non-negativity: Solution variables cannot be negative.**

6. **Finiteness: Limited, countable number of decision variables and constraints.**

Applications

- **Manufacturing and resource management.**
- **Supply chain and transportation.**
- **Workforce planning.**
- **Portfolio optimization.**

Graphical Solution of Two-Variable Problems

Graphical methods apply mainly to LP problems with two variables (x_1 and x_2). Steps:

1. **Formulate the problem.**
2. **Plot constraints as lines on the x_1,$x_2$plane.**
3. **Determine the feasible region (the intersection area satisfying all constraints).**
4. **Identify the objective function.**
5. **Find corner points (vertices) of the feasible region.**
6. **Evaluate the objective function at each vertex; the optimal solution will be at one of these points.**

Feasible Region

The area that satisfies all constraints is called the feasible region. A solution is feasible if it lies within this region and satisfies all constraints, including non-negativity.

Optimal Solution

The optimal value corresponds to the feasible solution (usually at a vertex) that maximizes or minimizes the objective function.

Standard Form of a Linear Programming Problem

Standard form is the canonical way to represent LP problems:

- **Maximize** $Z = c_1x_1 + c_2x_2 + \dots + c_nx_n$
- **Subject to:**
  - $a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n \le b_1$
  - $a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n \le b_2$
  - **...**
  - $x_j \ge 0$,**for all** j.**Special Cases in LP**

Infeasibility

Infeasibility occurs when no solution exists that satisfies all constraints (the feasible region is empty). This may result from conflicting or inconsistent constraints.

Unboundedness

An unbounded solution exists when the objective function can be increased or decreased indefinitely, indicating missing or incorrectly formulated constraints.

Alternative Optima

Multiple optimal solutions exist if the objective function is parallel to a constraint in the feasible region. In this case, more than one vertex provides the optimal value.

Degeneracy

Degeneracy occurs when more constraints meet at a vertex than necessary, potentially causing computational issues or multiple alternate optimal solutions.

Duality

Every LP problem (primal) has an associated dual problem where the objective and constraints switch roles. The optimal values of the primal and dual problems are equal under certain conditions.

Sensitivity Analysis

Sensitivity analysis studies how changes in coefficients (resource availability, costs/profits) affect the optimal solution. This is crucial for real-world applications where data may vary.

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