Chapter one: Introduction to Operations Research

1-1-Definition:

Operations Research (OR) is a multidisciplinary field that applies mathematical, analytical, and computational methods to solve complex decision-making problems. It provides a systematic and scientific approach to optimize processes, allocate resources, and improve organizational efficiency.

1-2 Origin and Background of Operations Research

Operations Research (OR) originated as a scientific discipline during the early 20th century. The term "Operational Research" was coined in 1940 by A.P. Rowe, a British Air Ministry scientist. It referred to the application of scientific methods to integrate and optimize new radar technologies for military use.

Inspired by British successes, the United States adopted OR during World War II. The first organized OR group in the U.S. was formed in 1942 at the Naval Ordnance Laboratory, focusing on mine warfare and submarine tactics.

After World War II, OR expanded into civilian industries, including manufacturing, transportation, and finance. It became a key tool for optimizing business processes and resource management.

Universities and professional societies began formalizing OR as an academic discipline, further advancing its methodologies.

1-3- Core Concepts of Operations Research

1. Mathematical Modeling:
    - OR relies heavily on mathematical models to represent problems. These models often include these key components:
        - Objective Function: Defines the goal, such as maximizing profit or minimizing cost.
        - Decision Variables: Represent the choices or actions available.
        - Constraints: Define the limitations or requirements of the system.
        - Feasible Region: The set of all possible solutions that satisfy the constraints.
        - Non-negativity of the decision variables.
2. Optimization:
    - Optimization is the backbone of OR, aiming to find the best possible solution from a set of feasible alternatives.
    - Techniques:

- Linear Programming (LP): Solves problems with linear relationships.
- Integer Programming (IP): Deals with discrete decision variables.
- Non-linear Programming (NLP): Handles non-linear relationships.
- Dynamic Programming (DP): Breaks problems into simpler subproblems with overlapping solutions.

3. Deterministic vs. Stochastic Models:
    - Deterministic Models: Assume certainty in all inputs and outcomes.
    - Stochastic Models: Incorporate randomness and uncertainty, often using probability distributions.
4. Simulation:
    - Simulation models replicate real-world systems to test different scenarios and predict outcomes without implementing changes in reality.
5. Queuing Theory:

- Focuses on analyzing and optimizing waiting lines or queues, commonly applied in service industries and transportation systems.

6. Network Analysis:
   - Models systems as networks of interconnected entities to optimize flows, such as transportation routes or supply chains.
7. Inventory Control:
   - Ensures optimal inventory levels to minimize costs while meeting demand.

1-4- Applications of Operations Research

- Supply Chain Management: Optimizing logistics, inventory, and transportation.
- Scheduling: Allocating resources like employees or machinery efficiently.
- Risk Management: Identifying and mitigating uncertainties.
- Urban Planning: Designing efficient layouts for cities and infrastructure.
- Healthcare: Resource allocation and patient flow optimization.

- Finance: Portfolio Optimization OR techniques are used to balance risk and return in investment portfolios.