National Seminar on Applications of Mathematics in Modern Science and Technology (20th May-2026)
Organized by: S.R. Government Arts & Science College Kothagudem, Telangana

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

Optimization Techniques and Operation Research

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Abstract- Operations Research (OR) is a multidisciplinary field that applies advanced analytical methods to support decision-making, resource allocation, and problem-solving in complex systems. Rooted in mathematics, statistics, and optimization techniques, OR provides systematic frameworks for analyzing challenges where competing objectives and constraints exist. By employing models such as linear programming, queuing theory, simulation, and network optimization, OR enables organizations to minimize costs, maximize efficiency, and improve service quality. Its applications span manufacturing, logistics, healthcare, finance, and public policy. For instance, OR helps industries streamline supply chains, hospitals optimize patient scheduling, and governments design efficient transportation systems. In essence, Operations Research bridges theory and practice, offering decision-makers structured tools to navigate uncertainty, evaluate alternatives, and achieve optimal outcomes in dynamic environments.

Keywords: Operations Research, Optimization, Decision-Making, Resource Allocation, Linear Programming, Simulation, Network Optimization, Queuing Theory, Operational Efficiency, Mathematical Modeling.

I.INTRODUCTION

Operations Research (OR) is a scientific approach to decision-making that uses mathematical models, statistical analysis, and optimization techniques to solve complex organizational problems.
World War II – The Birth of OR

- **Formal Origin (1940):** The term Operations Research was first coined by A.P. Rowe, Director of Scientific Research at the British Air Ministry.
- **Blackett's Circus:** A team led by Nobel laureate Patrick Blackett brought together scientists, mathematicians, and engineers to address urgent wartime challenges.

Key Contributions

1. **Anti-Submarine Warfare:** OR determined optimal depth charge settings, increasing submarine destruction rates.
2. **Convoy Sizing:** Studies showed larger convoys reduced losses, challenging traditional naval strategies.
3. **Radar Deployment:** OR optimized radar placement and fighter interception strategies during the Battle of Britain.
4. **Aircraft Utilization:** Analysis of bomber missions improved formation flying, fuel efficiency, and target selection.

Meaning of Operations Research

Operations Research transforms real-world problems into structured frameworks, enabling organizations to identify the best possible solutions under given constraints.

International Journal of Science, Engineering and Technology
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- **Churchman, Ackoff, and Arnoff (1957):** Defined OR as a scientific method providing executives with a quantitative basis for decisions.
- **T.L. Saaty (1958):** Applied OR to military logistics, resource allocation, and systems analysis, emphasizing probability models, game theory, and optimization.
- **Fabrycky and Torgersen:** Advanced the systems approach, lifecycle costing, and decision analysis, integrating OR into engineering and management education.

Scope of Operations Research

1. **Resource Allocation:** Optimal use of manpower, machines, materials, and money.
2. **Production & Manufacturing:** Scheduling, inventory control, and quality management.
3. **Transportation & Logistics:** Vehicle routing, fleet management, and supply chain optimization.
4. **Healthcare & Public Services:** Hospital scheduling, patient flow, and resource distribution.
5. **Finance & Economics:** Portfolio optimization, risk management, and cost-benefit analysis.
6. **Government & Defense:** Military logistics, disaster planning, and policy design.
7. **Modern Applications:** Smart cities, sustainability, AI-driven decision-making, and big data analytics.

Limitations of Operations Research

1. Dependence on accurate data.
2. Mathematical complexity in large-scale problems.
3. Implementation challenges due to organizational resistance.
4. Difficulty adapting to dynamic environments.
5. High cost and time requirements.
6. Limited consideration of human and social factors.

Linear Programming Problem (LPP) – Step-by-Step Formulation

1. **Identify Decision Variables:** Define unknowns representing choices (e.g.,x= units of product A, Y= units of product B).
2. **Formulate Objective Function:** Express the goal mathematically (maximize or minimize).
    - Example: Maximize profit ($Z = 40X + 30Y$).
3. **Establish Constraints:** Translate resource limitations into inequalities.
    - Example: ($2X + Y \leq 100$).
4. **Include Non-Negativity Restrictions:** Ensure (x_1, x_2 ≥0).

Example LPP Model

Maximize:
[$Z = 40X + 30Y$]
Subject to:
[$2X + Y \leq 100$]
[$X + Y \leq 80$]
[$X, Y \geq 0$]

To Solve the real life software startup issues by using

<u>Hungarian method</u>.

Example: A startup has **three new feature requests**:

- **F1:** User Authentication Upgrade

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- **F2:** Data Visualization Dashboard
- **F3:** Mobile App Integration

There are **three developers** available:

- **D1:** Expert in backend systems
- **D2:** Skilled in UI/UX design
- **D3:** Experienced in mobile development

The challenge is to **assign features to developers** in a way that maximizes efficiency and minimizes completion time.

Step 1 – Decision Variables

Let:

- $x_{ij} = 1$ if feature F_i is assigned to developer D_j, otherwise 0.

For example:

- $x_{11} = 1$ means F1 is assigned to D1.
- $x_{23} = 1$ means F2 is assigned to D3.

Step 2 – Objective Function

Suppose each developer has an estimated completion time (in days) for each feature:

Feature/Developers	D1 (Backend)	D2 (UI/UX)	D3 (Mobile)
F1	5	8	7
F2	9	4	6
F3	7	6	3

The objective is to **minimize total completion time**:

$$Z = \sum_{i=1}^{3} \sum_{j=1}^{3} c_{ij} \cdot x_{ij}$$

Step 3 – Constraints

1. **Each feature must be assigned to exactly one developer:**

$$\sum_{j=1}^{3} x_{ij} = 1 \quad \text{for all } i$$

2. **Each developer can handle at most one feature (if workload is limited):**

$$\sum_{i=1}^{3} x_{ij} \leq 1 \quad \text{for all } j$$

3. **Binary restriction:**

$$x_{ij} \in \{0, 1\}$$

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Step 4 – Example Solution (Hungarian Method)
Using the **Hungarian Algorithm** for assignment problems, the optimal assignment would be:

- F1 → D1 (5 days)
- F2 → D2 (4 days)
- F3 → D3 (3 days)

Total completion time = **12 days** (minimum possible).

To Solve the real-life problems by using optimization techniques (graphical method)
Example: Buying Fruits with a Budget
Suppose you go to the market with **₹100**.

- Apples cost **₹20 each**.
- Bananas cost **₹10 each**.

You want to know all possible combinations of apples ((x)) and bananas ((y)) you can buy.
Step 1: Constraint
[$20x + 10y \leq 100$]

Step 2: Simplify
[$2x + y \leq 10$]

Step 3: Graphical representation

- Draw the line ($2x + y = 10$).
- The feasible region is **below the line** (since it's ≤).
- Points like (0,10), (5,0), (3,4) are possible solutions.

Step 4: Real-life meaning

- If you buy **5 apples**, you can't buy any bananas.
- If you buy **10 bananas**, you can't buy any apples.
- If you buy **3 apples**, you can still buy **4 bananas**.

The graph shows all combinations you can afford with ₹100.

"Optimizing Travel Routes with PERT METHOD and Google Maps"

Example: Driving from Home (A) to Office (D)
You have two possible intermediate intersections: **Point B** and **Point C.**
So, there are two possible routes:

1. **Route 1:** A → B → D
2. **Route 2:** A → C → D

Google Maps Distances (example values)

- A → B = 5 km
- B → D = 10 km
- A → C = 8 km
- C → D = 7 km

Travel Time Estimates (using PERT)
For each segment, we take **Optimistic (O), Most likely (M), and Pessimistic (P)** times from Google Maps (light traffic, normal traffic, heavy traffic).

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- **A → B:** O = 8 min, M = 10 min, P = 12 min

$$TE = \frac{8 + (4 \cdot 10) + 12}{6} = 10 \text{ min}$$

- **B → D:** O = 15 min, M = 20 min, P = 25 min

$$TE = \frac{15 + (4 \cdot 20) + 25}{6} = 20 \text{ min}$$

- **A → C:** O = 12 min, M = 15 min, P = 18 min

$$TE = \frac{12 + (4 \cdot 15) + 18}{6} = 15 \text{ min}$$

- **C → D:** O = 10 min, M = 12 min, P = 15 min

$$TE = \frac{10 + (4 \cdot 12) + 15}{6} = 12 \text{ min}$$

Route Comparison

- **Route 1 (A → B → D):** 10 + 20 = **30 min**
- **Route 2 (A → C → D):** 15 + 12 = **27 min**

According to PERT, the **expected shortest route is A → C → D (27 min)**.

REFERENCE

S.D. SHARMA (OPERATIONS RESEARCH)