



OPERATIONS RESEARCH

Designed for the students of CSE/ISE and MCA

3rd Edition



Sreenivasa Reddy M

SANGUINE

OPERATIONS RESEARCH

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Third Edition

M. SREENIVASA REDDY

Professor & Head

Department of Mechanical Engineering,

R. L. Jalappa Institute of Technology,

Doddaballapur -561 203

Karnataka, India.



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This Book is dedicated to

***My parents who showed the path,
My teachers who guided me through.***

PREFACE

“*Optimal utilization*” of resources is one of the fundamental aspect in commercial success of an organization”. Operations Research is a group of optimization techniques of effective utilization of resources subject to a set of constraints with the objective of minimization of cost or maximization of profit to an organization.

Operations Research is an easy subject if taught well and learnt systematically. This is further augmented if complemented by a good book. In my years of teaching and training I came across a number of books on the subject but many of them would not meet specific requirement of the students. The students find the usual books too bulky considering the time constraint they have in the semester scheme. This has promoted me to write this book specifically for the students of Visvesvaraya Technological University as per the syllabus. This book meets the complete requirement of the students of Computer Science and allied courses. I have adapted, assimilated and expanded my class room notes by enlarging its scope based on student feedback over the years to develop this book.

It is a joy to write preface to the new edition as it shows the acceptance of the first edition. The enthusiastic response received from the students and faculty encouraged me in bringing out this edition. It is my humble admission that the new edition is entirely due to the felt needs of the teaching faculty as well as the students expressed to me during my many interactions both on and off campus. During the past two years, I have felt that there was a scope for improvement of the book, which complemented the feelings of both faculty and students. This edition is the result of these confabulations.

The revision of the text has been extensive with the objective of further enhancing and strengthening the conceptual as well practical knowledge about various techniques of Operations Research. Almost every chapter has been reorganized and re-written to make explanation more cogent through relevant and interesting examples. Thus, this edition is a completely a new book.

I am confident that the teaching faculty as well as the students will find this book very useful not only for their academics but also outside it. I believe that “Success is a journey, not a destination”, any suggestions for further improvement of the contents are most welcome, will be thankfully acknowledged and incorporated in the subsequent editions.

Please mail your suggestions to: *sreenivasa.m123@gmail.com*

Wishing you to learn with pleasure....

PREFACE TO THE FIRST EDITION

Operations Research is an easy subject if taught well and learnt systematically. This is further augmented if complemented by a good book. My first book was well received by the faculty and students of mechanical engineering and allied subjects. With the increased usage of computers and current technologies to solve many managerial problems, there has been a very strong felt requirement for a book specifically to meet the requirements of computer science and information science students. Many of my colleagues notably Prof. Gorabal J.V, Head, Computer Science Engineering, RLJIT and Prof. Thippeswamy K, Head, Information Science Engineering, RLJIT, suggested and encouraged me to write a book specifically meeting the complete needs of Computer Science, Information Science Engineering and Master of Computer Applications students. This book is a result of that endeavor.

Operations Research as an art and science has an important role to play in today’s world where technology intervenes in every aspect of our lives. Transforming OR as a key ingredient of this technology ruled world where management and decision making is considerably automated has become critical. Understanding this aspect, many students of computer science and information science are opting for Operations Research as an elective subject to get a better handle in their future assignments as professionals. This book is my humble attempt to add value to their vision. Suggestions to improve this volume are most welcome.

ACKNOWLEDGEMENTS

The euphoria that entails the triumphant completion of any undertaking would be incomplete without applauding and thanking the people who made it possible. I would like to hereby acknowledge their abundant support in bringing out this book. It gives me immense pleasure in recording my deep sense of gratitude to all the concerned. I profusely thank all the concerned who have encouraged and suggested in bringing out this edition.

I express my heartfelt thanks to Sri. Lal M Prasad and Sri. Kamalakar Pandit of Sanguine Technical Publishers (India), Bangalore, a leading technical and professional core publisher for coming forward to publish this book with bestowed confidence on me.

I take this opportunity to acknowledge with profound regards to Sri. R. L. Jalappa, Hon'ble Chairman, Sri G.H. Nagaraja, Secretary - Sri Devaraj Urs. Educational Trust, Kolar, Sri. J. Nagendraswamy, Chief Executive Officer - R. L. Jalappa Group of Institutions, Doddaballapur, Sri. J. Rajendra, Director (Admin.), Dr. A. N. Nanda Kumar, Principal, R.L.J.I.T., for their encouragement and support extended to me in all aspects, throughout. I wish to extend my thanks to Mr. Yateesh, Head-HR, faculty and head of all departments of R.L.J.I.T., for their unrelenting support. I will be failing in my obligations if I do not admit the bountiful support and well wishes of my dear colleagues of Department of Mechanical Engineering, R.L.J.I.T.

Special thanks to Sri. Machayya C. M., Proprietor - Interline Publishing, Bangalore, who is fundamentally responsible for me to undertake this task and for all his motivation, guidance and generosity extended to me at every stage in bringing out this book.

Working on this edition was made possible by the support of my family members who share the dream with me that ultimately the only thing that matters is excellence. I wish to extend my sincere thanks to M/s. Sharvani Inc., Bangalore for their concern and excellent typesetting work.

I am grateful to several teachers and reviewers from whom I received comments and suggestions which have helped me to improve the contents of this book. I thank them for their generous efforts, time and contribution.

I wish to extend my special thanks whole heartedly to one and all helped me out directly or indirectly in bringing out this book.

M. Sreenivasa Reddy

Guidelines for Successful Learning

Dear Students,

Operations Research (OR) is an interesting and scoring subject. A little focus can land you to the best Grade in exams.

1. *OR as a subject is distinct. Usually the question paper will be with Numericals.*
2. *OR cannot be learnt overnight, practice is a must.*
3. *Understand the theoretical concepts before attempting to crack a problem.*
4. *Read and analyse a problem clearly before attempting to solve it.*
5. *Never try to remember concepts, understand them.*
6. *Prepare your own ready reckon, for instant reference.*
7. *Equate the problems to your real life and this will help you to use appropriate method in solving them.*
8. *Concentrate while attempting to solve a problems. Relate it to the theoretical concept. Make sure no mistakes are crept in the procedure. Debugging is a tedious and time consuming process.*
9. *Systematic understanding of the solved problems and practicing the Exercise Problems given in this book will surely enhance your confidence to face the Examination. Never be nervous, a little thinking will help you to co-relate with the solved examples and Crack it.*
10. *Mainly train your mind to learn with pleasure, which will make anything to everything possible.*

Wishing you all the best and Happy Learning...

- Author

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1

Introduction, Linear Programming – 1

1.1 INTRODUCTION

Operations Research (OR) is an art and science concerned with the efficient allocation /utilization of limited resources. The art lies in the ability to depict the available resources in a well-defined mathematical model for a given situation. The science consists in the derivation of computational methods for solving such models. Whether it is a company, a farm, or even a domestic kitchen, resources of men, machine, material, money etc.. have to be utilized in a most efficient manner.

In this regard, the management has to constantly analyze the existing situation and make proper decisions.

Decision-making is always a complex activity as it affects the decision-maker as well as others. For example a student has to decide the course he / she should take for study and the decision will affect not only the student but also everybody related to his / her life and activities. The same principle applies to a person seeking employment where he / she has to chose the job or service. Therefore, one has to develop his / her talents in such a way that he / she is in a position to take a correct decision at a proper time. Effective decision making depends on many factors such as economic, social and political. For example starting a new firm/business at a place would depend on economic factors such as construction costs, labour availability/ costs, availability of raw materials, transportation costs, taxes, energy, pollution control costs, etc.

Decision making in business and industry is extremely challenging as it affects many people from a wide spectrum of society. Generally decisions are taken with the help of past experience and

instructions but some formal system is needed to determine an effective course of action. Operations Research (also known as Optimization Techniques, Management Science and by few other names) provides a quantitative technique or scientific approach to the executives for making better decisions for operations under their control. In other words, OR provides a scientific approach to problem solving.

OR basically helps in determining the best (optimum) solution to problems where decisions need to be taken under the restriction of limited sources. It is possible to convert any real life problem into a mathematical model. The basic feature of OR is to formulate a real world problem as a mathematical model. In general, to management of organisations concerned with lowering labour costs or production costs or transportation costs to achieve higher profits, OR can be very usefully employed to minimize the costs/ maximize the profits (Optimization).

1.2 WHY TO STUDY OPERATIONS RESEARCH? (IMPORTANCE OF STUDYING OR)

OR basically helps in determining the best (optimum) solution to problems where decision has to be taken under the restriction of limited resources. Any organization involving operations (transportation, job allocation, marketing) want to lower their operation costs to achieve higher profits, OR can be very usefully employed to this kind of real life problems.

With computers moving up the corporate ladder, the managers are increasingly using the operations research techniques for the purpose of decision – making with a view to arrive at optimal decisions. Thus, an understanding of various important techniques which can be used to aid the managerial decision making process is desirable for engineers / managers.

Industry has become quite aware of the potential of OR as a technique and many industrial and business houses have OR teams working to find solutions to their problems.

1.3 DEFINITIONS OF OPERATIONS RESEARCH

Operations Research has been defined so far in various ways and it is perhaps still too young to be defined in some authoritative way. Students must understand that it is not possible to give uniformly acceptable definition of OR. A few opinions about the definitions of OR are,

“OR is a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control” – Morse and Kimbol – 1946

“OR is the scientific method of providing executives an analytical and objective basis for decision” – P. M. S. Blackett – 1948

“Operations Research is a scientific approach to problem solving for Executive Management”
– H. M. Wanger

“Operations Research is concerned with scientifically deciding how best to design and operate machine systems usually under conditions requiring the allocation of scarce resources”

–OR Society of America

“OR is the scientific knowledge through inter disciplinary team efforts for the purpose of determining the best utilization of limited resources”

– H. A. Taha

“Operations research is an art of winning a war without actually fighting”

– Aurthur Clark

“Operations research is the application of the methods of science to complex problems arising in the direction and management of large systems of men, materials and money in industry, business, government and defense”

– Operations society of Great Britan

The above discussed definitions are given by various people at different times and stages of development of operations research lays emphasis on

- i. OR being a scientific technique
- ii. It is a problem solving technique
- iii. It is for the use of executives who have to take decisions for the organizations.

A close observation reveals that, almost all the definitions are conveying the same meaning.

1.4 ORIGIN OF OPERATIONS RESEARCH (HISTORICAL DEVELOPMENT OF OR)

The term, operations research was first coined in 1940. This new science came into existence in a military contest. During World War–II, Military Management in England called upon a team of scientists to study the strategic and tactical problems related to air and land defense of the country. They were having limited resources and it was necessary to decide upon the most effective utilization of them. (Effective ocean transportation, effective bombing etc). **Mc Closky** and **Trebthen** of Bowdsey, **United Kingdom** used the term Operations Research in 1940 to describe this new science.

The OR teams were not actually engaged in military operations and fighting the war. But, they were only instrumental and advisors in wining the war by providing a good intellectual support to the strategic initiatives of the military commands (that is, “An art of wining the war without actually fighting”). As the team was dealing with research on military operations, the work of this team of scientists was named as Operations Research in England.

Following the end of war, the success of military teams attracted the attention of industrial managers who were seeking solutions to their complex executive type problems. Thus, it started spreading throughout the world and Society of Operations Research was formed in United States.

Today the impact of OR is felt on many areas. A large number of management consulting firms are currently engaged in OR activities.

1.5 IMPACT OF OPERATIONS RESEARCH (APPLICATIONS / SCOPE OF OR)

The scope of Operation Research is far and wide. In recent years OR has successfully entered many different areas of research in defense, government, service organizations and Industry. Not all applications of OR can be listed, as OR is a tool finding new applications every day. OR has had an impressive impact on improving efficiency of various organisations across the world.

Some Areas of Applications

- i. Optimal allocation of resources.
- ii. Finding the optimal trajectories of missile vehicles.
- iii. Design of aircraft and aerospace structure with high strength and low-weight.
- vi. Design of structures like frames, bridges, chimneys, dams etc., at minimum cost.
- v. Selection of best location for an organization.
- vi. To find shortest route taken by a salesman, visiting different cities.
- vii. Optimum design of electrical / cable networks.
- viii. Optimum production planning, controlling and scheduling.
- ix. Selection of an optimum strategy.
- x. In finding solutions for various business problems.

These can be summarized / classified into various areas or fields as follows.

i. Production Management

- a. Scheduling and requesting the production run by proper allocation of machines
- b. Obtaining optimum product mix.
- c. Selection, location and decision of the sites for the production plans.

ii. Purchasing Decision

- a. Inventory (Stock) management
- b. Optimal re-ordering

iii. Facilities Planning Management

- a. Transportation, loading and unloading
- b. Planning warehouse locations
- c. Factory/building location and size decisions

iv. Construction Management

- a. Location of resources to different projects
- b. Work force/labour planning
- c. Project management

v. Personnel Management

- a. Forecasting the man-power requirements, recruitment policies and job assignments
- c. Selection of suitable personnel with due consideration for age and skills etc.

Operations Research



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Author : M. Sreenivasa Reddy

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