DECISION SCIENCE

Dr. A.B. Rao

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PREFACE

This book has been written with the specific objective of meeting the requirements of the **MBA students of Savitribai Phule Pune University** for studying the subject of 'Decision Science' in accordance with prescribed syllabus.

The important features of this book are:

(a) Lucid explanation of the theoretical principles.

(b) Solved problems in a number of chapters.

(c) Exercises at the end of each chapter.

My sincere thanks to the publishers for bringing out this book with zeal. Suggestions for the improvement of this book will be thankfully received.

Dr. A.B. Rao

SYLLABUS

Unit	Details	No. of Sessions
I	**1.1 Introduction:** Importance of Decision Science and Role of Quantitative Techniques in Decision Making. **1.2 Assignment Models:** Concept, Flood's Technique/Hungarian Method, Applications including Restricted and Multiple Assignments. **1.3 Transportation Models:** Concept, Formulation, Problem Types; Balanced, Unbalanced, Minimization, Maximization, Basic Initial Solution using North West Corner, Least Cost and VAM, Optimal Solution using MODI.	**9 + 2**
II	**2.1 Linear Programming:** Concept, Formulation and Graphical Solution. **2.2 Markov Chains and Simulation Techniques:** Markov Chains, Applications Related to Management Functional Areas, Implications of Steady State Probabilities, Decision Making Based on Inferences, Monte Carlo Simulation, Scope and Limitations.	**8 + 2**
III	**3.1 Decision Theory:** Concept, Decision under Risk (EMV) and Uncertainty. **3.2 Game Theory:** Concept, 2 by 2 Zero Sum Game with Dominance, Pure and Mixed Strategy. **3.3 Queuing Theory:** Concept, Single Server (M/M/I, Infinite, FIFO) and Multi Server (M/M/C, Infinite, FIFO).	**6 + 2**
IV	**4.1 CPM and PERT:** Concept, Drawing Network, Identifying Critical Path **Network Calculations:** Calculating EST, LST, EFT, LFT, Slack and Probability of Project Completion. **4.2 Sequencing problems:** Introduction, Problems Involving n Jobs-2 Machines, n Jobs-3 Machines and n Jobs-m Machines; Comparison of Priority Sequencing Rules.	**6 + 2**
V	**5.1 Probability:** Concept, Addition, Conditional Probability Theorem Based Decision Making (Numerical Based on Functional Areas of Business Expected). **5.2 Probability Distributions:** Normal, Binomial, Interval Estimation, Standard Errors of Estimation.	

CONTENTS

1 Quantitative Techniques: Statistics and Operations Research

1.0. DECISION SCIENCE

The subject matter Decision Science essentially consists of various 'Quantitative Techniques' involving statistical and as well as 'Operations Research Methods. In the process of decision making it is necessary to use relevant statistics and appropriate methods of Operations Research.

The meaning, scope, importance and other features of 'statistics' are explained below. Also, the characteristics, importance and limitation of 'Operations Research, have been explained in the pages that follow.

1.2 MEANING OF STATISTICS

In a broad sense, statistics was born when man first began to count and express his ideas and sensible facts in quantitative terms – that is, in numbers. Civilization's progress could have been held at bay but for the discovery of numbers, for indisputably its growth through the centuries has been nurtured by numbers.

The use of statistics dates back to ancient times when the Pharaohs and the Hebrews took censuses of population and wealth time to time. Ancient kings maintained records on population, wealth, area of land, crop yields, livestock, births and deaths etc., in their kingdoms. As a result, statistics came to be known as the 'Science of Kings'.

Statistics were collected even in ancient India, during the reign of the Mauryan and the Gupta kings. According to Kautilya's treatise on statecraft, the Arthashastra, the Mauryan kings undertook the task of collecting statistics on population, agriculture, etc., from time to time. The Mughal emperors, too, maintained statistics of population, land, agriculture; the *Ain-i-Akbari*, for instance, provides statistical details during the reign of Emperor Akbar (1556-1605).

The Latin word '*status*' and the Italian word '*Statista'* both mean a political state and it appears that the word statistics has been derived from both of them. The definition of statistics become broader and broader as it developed from century to century. The emergence of statistics in the modern form is largely due to the influence, keen interest and work of great mathematicians of the eighteenth and nineteenth centuries. At present, statistics is used in all fields of human activity and has come to be regarded as indispensable to the study of many sciences, especially the social sciences.

1.3 DEFINITION AND SCOPE OF STATISTICS

When used in the singular, the word 'statistics' means the subject of statistics. In the plural, it means quantitative information or numerical data. Various authors defined statistics in different ways, emphasizing various viewpoint. A.L. Bowley, for instance, has given four definitions:

"Statistics is the science of the measurement of social organisms regarded as whole in all its manifestations."

"Statistics may be called the science of counting."

"Statistics are numerical statements of facts in any department of enquiry, placed in relation to each other."

"Statistics may rightly be called the science of averages.

Each of these definitions stresses only one viewpoint or aspects of the variety and richness of statistics, for it is not only concerned with applications to sociology, averages, counting or figures but with many other things. Hence, these definitions have their own limitations.

Bowley also defines statistics as the 'Science of estimates and probabilities'. While there's no doubt that in a large number of cases it deals with estimates and probabilities, but again these are not the only methods or aspects of statistics.

Webster (Dictionary Definition) defines statistics as 'Classified facts respecting the condition of people in the state – especially those facts which can be stated in a table or tables of numbers or in any tabular or classified arrangement.' This definition is inadequate as it stresses only on one aspect of statistics: classification of facts – in a table or tables of numbers – regarding the condition of people in the state. It does not mention its applications in other fields like biology, physics, sociology, economics, metrology or astronomy.

According to Udney Yule: "By statistics we mean quantitative data affected to a marked extent by multiplicity of causes." This definition, too, emphasizes on only one aspect of statistics, omitting its other important characteristics.

W.I. King defines it thus: "The science of statistics is the method of judging collective natural or social phenomena from the results obtained by the analysis of an enumeration or collection of estimates." Though this definition is a remarkable one, it could have emphasized the all-pervading or all embracing aspects of statistics.

According to Horace Secrist: "By statistics we mean aggregates of facts affected to a marked extent by multiplicity of causes numerically expressed, enumerated or estimated according to reasonable standards of accuracy, collected in a systematic manner for a predetermined purpose and placed in relation to each other." This definition is comprehensive and exhaustive and covers most of the aspects of statistics. It's certainly very close to the definition of modern statistics, but yet, it could have been broader.

In this modern scientific, technological, industrial, space-conquering, planet-probing and atomic age, statistics and statistical techniques have entered a new epoch and are being increasingly and advantageously used in every sphere of human knowledge. Just as a few mathematical equations symbolize the unknown depths of hidden facts, so also statistical facts provide a good deal of information. And with the growing realization of the indispensability of statistical knowledge – it being all-pervading and all-embracing – its definition will broaden and glitter at the hands of capable statisticians. However, it must be accepted that it's not easy for any capable statistician to come up with a definition of statistics that will remain relevant forever. But talented authors and statisticians are coming up with more elegant, refined, comprehensive and exhaustive definitions from time to time.

The modern view of statistics is that it is not just the art of collecting, sorting, classifying, grouping, summing up and using numerical facts. It is also a science that provides the tools and techniques that can be used advantageously to measure and analyse facts in any sphere of human knowledge.

Though reputed authorities on the subject have given remarkable definitions one more may be added to them; "Statistics, in the singular, is the subject that explains all the devices of collection, presentation, analysis and inference of numerical facts and figures in any field of knowledge, and in the plural, stand for any sensible statements of numerical facts which can be analysed, interpreted, compared and related if possible."

1.4 STATISTICAL METHODS AND APPLIED STATISTICS

Statistics is divided into two main divisions: statistical methods and applied statistics. Statistical methods or the theory of statistics is also known as mathematical statistics as it developed mainly through mathematics. The theory of statistics has the mathematical theory of probability as its basis; statistical methods deal with the formulation of devices or general rules of procedure that can be employed in handling different types or forms of data. For instance, the rules for the collection of data, classification, tabulation, analysis, comparison by averages and the methods of finding the coefficient of correlation, regression equations and coefficients and index number construction are all statistical methods.

The theory of statistics is further divided into statistical inference and the design of experiments. Statistical inference involves drawing inferences or valid conclusions from a sample of any population. These conclusions are concerned with the specification of the population from the information supplied by the sample. Design of experiments is concerned with design for the collection and analysis of data. Experiments are conducted on the basis of these to test and verify the validity of hypotheses. Therefore, selecting the design is of the utmost importance; a wrong one inevitably leads to fallacious and absurd conclusions in the course of experimentations.

Applied statistics deals with practical applications and using statistical methods to tackle concrete problems like population, agriculture, industry, trade and transport, wages and prices of commodities. Economic statistics; which is a branch of applied statistics, deals with statistics of prices, production, income, expenditure, etc.

Applied statistics has several branches. Some of these are:

1. Financial statistics: These are statistics of public finance, money, banking, currency and exchange.
2. Population statistics: These form a part of demography, which is a collective and detailed statistical study of human life with reference to population growth and vital and social aspects.
3. Agricultural statistics: These deal with area, yield of crops, livestock, etc.
4. Industrial statistics.
5. Labour employment statistics.
6. Administrative statistics.
7. Social statistics.

8. Trade and transport statistics.
9. Price statistics.
10. National income statistics.

Statistics of consumption, production, exports, imports, prices and wages help in framing economic policies. Economic growth is determined to a considerable extent by certain statistical measures like index numbers, etc.

1.5 STATISTICS AND MATHEMATICS

The science of statistics owes its development and progress to the mathematical theory of probability. Statistical methods owe a great deal to mathematicians.

One of the first to sow the seed of the idea of probability was Jerome Cardano (1501-1536), a gambler and mathematician, who came up with rules to minimize risks in gambling and precautions against cheating in his book *'Liber De Ludo Aleae'*. Another step in this direction was taken in the year 1654, when another gambler and amateur mathematician, Chevelier-de-Mere, communicated a problem in a game of dice to the French mathematician Pascal. Pascal in turn passed it on to Fermat, another French mathematician. Later, these ideas were taken forward by mathematician Jacob Bernoulli (1654-1705), who first explained the law of large numbers in his book *'Ars another Conjectandi'* and another mathematician Daniel Bernoulli (1700-1782), who expressed the idea of 'mortal expectation'. They laid the first foundations of the modern theory of probability.

Years later, mathematicians like Laplace (1749-1827), Gauss (1777-1855) and S. Poisson (1781-1840) made significant contribution to probability and statistical theory. In this manner, eminent men – mathematicians, statisticians, social scientists and research workers in diverse fields - contributed to the development, enrichment and progress of the theory of statistics over the generations. The following are some of the notable men who contributed to the growth and development of statistics:

Euler, Lagrange, De Moiver, Knapp, Lexis, Morgan, Charlier, August Meitzen, Devenport Francis, Edgeworth, Francis Galton, Karl Pearson, Udney Yule, W.W.Gossett, A.L.Bowley, Adams, W. I. king, W. Pearson and R.A Fisher.

1.6 STATISTICS AND ECONOMICS

There is a great of interrelationship and interdependence between statistics and economics. Economists have to use mathematical methods and statistical procedures to make more intensive, accurate and detailed studies of economic problems. According to economist Alfred Marshall: "Statistics are the straw out of which I, like every other economist, have to make bricks."

One of the earliest to use statistics in economics was an Englishman called John Graunt (1620-1674) who wrote his book, *Natural and Political Observation*…upon the Bills of Mortality after thoroughly studying the records of births and deaths in the cities of England in the year 1662. A few years later, in 1676, Sir William Petty (1623-1685) published his *Political Arithmetic* in which he insisted upon the use of statistical methods in studying social phenomena.

In 1871, W.S. Jevons (1835-1882) published his *Theory of Political Economy* in which he said political economy could be made an exact science by using more detailed commercial statistics.

Further, the Historical School (1834-1883) also advocated the use of statistical techniques in economics. Alfred Marhsall, Pareto, Lord Keynes and F. Y. Edgeworth relied on a lot statistical detail in their works on economics.

1.7 STATISTICS AND ECONOMETRICS

Statistics is also closely related to econometrics, a subject of recent origin. Econometrics is more or less a sensible synthesis of economic theories, their mathematical symbols and expressions and certain statistical procedure that verify these theories. In other words, it is formulation of economic theories in mathematical terms and the examination of these theories in the light of statistical methodology to find out whether they can be accepted or rejected in practical and real life situations. Econometrics is to be distinguished from statistical economics, mathematical statistics and mathematical economics, all of which are quite different from each other.

While statistical economics deals with economic data in quantitative terms, mathematical statistics is concerned with the general rules of procedure and devices that can be used to handle different types of quantitative data. Mathematical economics explains economic theories in mathematical terms.

1.8 Use of Statistics in Trade, Commerce and Industry

Wherever there is anything to be counted – in any area of trade, commerce or industry – you can find statistics there. 'Statistics provide the businessman a beacon of light that he can use to profit and progress. A businessman with a sound statistical knowledge of his entire business may do well. Without it, he will perish.

Useful for insurance companies. Using the law of Statistical Regularity – of statistics of births and deaths due to various causes – their actuaries can calculate insurance premiums.

Statistics also contribute a great deal to human welfare. Modern statistical techniques are the key to industrial progress because when these techniques - quality control, market research, etc., – are properly used they lead to increased profits, reduce wastage of materials and labour and enable businessmen to take informed decisions while selling and purchasing. The tools of statistical analysis may not lead us to peaks of precision or to depths of illusion, but they certainly do show us the practical levels of human expectation in quantitative terms.

Both small and large companies can profit by maintaining statistical departments and employing expert statisticians. Such departments collect and analyse data relating to the industry, prepare statistical charts, diagrams and maps, design and execute market research surveys, furnish periodical progress reports and give sensible statistical advice to business executives. Undoubtedly, statistics and statistics and statisticians are indispensable to trade, commerce and industry.

1.9 USES AND LIMITATIONS OF STATISTICS

I. A given of complex quantitative data can be simplified by using statistical methods. The results can be numerically, measured, comparisons can be made and relationships observed.

II. Statistics enriches knowledge and widens human experience.

III. Planning, which is critical in the twenty-first century, is to a large extent dependent on statistical results. Statistics not only helps to lay the foundations, it also provides the brick and mortar of all efficient and wise planning.

IV. Businessmen can increase profits by using statistics extensively. Thus, commerce flourishes in statistics and statistics flourish in commerce.

V. The diverse applications of statistics methods are so stupendous that people of each generation and men in every field can gain immensely and lose nothing. The modern age is remarkably statistical in character.

Limitations:

1. Every body of knowledge has its own limitations and so also statistics. Statistics is concerned with quantitative data and not with descriptive or qualitative facts.
2. Statistics as a science deals with groups of numerical items and not with individual items. The group, not the individual item, is its target.
3. Statistics, more or less, are numerical results expressed as approximations and estimates.
4. Statistical laws are not as accurate or exact as pure scientific laws but are quite dependable on an average, and to a large extent. After all statistics is considered a social science.
5. It is not always possible to study all aspects of a problem only through statistics for statistical facts and figures throw light only on some areas.

1.10 CHARACTERISTICS OF OR (OPERATIONS RESEARCH)

(i) OR provides a planned and scientific approach to the solving of problems.

(ii) Experts from various disciplines will have to use their expertise for finding appropriate and effective solutions to problem. Therefore, an interdisciplinary approach has to be adopted.

(iii) OR procedures lead to scientific answers based on analytical processes and not on intuition or individual judgment.

(iv) Decision making becomes scientific and consistent when OR methods are appropriately used.

(v) The methods of OR are qualitative and this is the main characteristic that enables OR experts to solve complicated problems, whether in business or in real life.

1.11 MATHEMATICAL MODELS IN OR

The following are some of the useful categories of models in OR.

(i) Deterministic and probabilistic models: When the outcomes of various courses of action can be predetermined and estimated, then the models used for quantitative evaluations are known as deterministic models. If the results of various courses of active cannot be predicted due to certain uncertainties, then the models that form basis of such estimates are called probabilistic models. Examples of deterministic models are those pertaining to Linear Programming. Whereas problems based on queuing theory can be attributed to probabilistic models.

(ii) Qualitative and quantitative: There are situations in business and industry where quality aspects prevail and their quantifications becomes a necessity for the purposes of analysis through OR procedures. Hence, qualitative problems becomes amenable in quantitative terms so as to be dealt with by OR techniques.

(iii) Descriptive and optimizing: On the basis of some records or past data of some real situations, a decision maker tries to fit an appropriate model more or less within a mathematical framework. For doing so, he/she has to describe various aspects of the real problem. In other words, the decision maker can't begin with precise mathematical formulations but has to use descriptive procedures.

In case of alternative solutions for a problem, the decision maker has to find out the best choice amongst such solution. He/she verifies the validity of the most optimal solution by carrying out certain tests. Hence decisions should not be based upon some feasible solutions, but on the solution that proves to be optimum.

(iv) Simulations and non-simulation models: These are real situations that give rise to certain problems that can be tackled by the applications of mathematical or statistical procedures as in the case of assignment or queuing problems. When problems are not amenable to mathematical formulating, then artificial procedures of adjustment can be resorted to. These procedures relate to the process of simulation.

Problems pertaining to linear programming or transportation can be solved by mathematical and statistical techniques and hence, the question of manipulation or adjustment arises. Therefore, such problems are called non-simulations models.

(v) Static and dynamic models: Static models are those concerned with definite answers to problems that are based on certain stipulations. Irrespective of the passage of time, a fixed solution is the characteristic of a static mode. For instance, programming models can be termed as static models. In case of dynamic models, time and change are the influencing factors in arriving at solution. Decisions to problems in certain situations change with time. Environment and circumstances in business and industry of yester years my not hold good in the present year. Hence, decisions have to change. All such decisions are based on dynamic models. The subject matter of dynamic programming deals with dynamic models.

Since the primary set of objectives before business executives are to minimize cost of production and at the same time maximise turnover, maximise sales and profits, minimize wastage, improve quality, maintain morale and maintain high productivity and efficiency amongst the various sections of employees, it is all the more necessary, at present, to set up Operations Research Teams consisting of talented experts belonging to various fields of knowledge.

1.12 OPERATIONS RESEARCH TEAMS, PROJECTS AND PROBLEMS

Generally, the setting up of an OR Team involves the selection of the following essential personnel:-

(1) A specialist in scientific methodology.

(2) A mathematician who is also an expert statistician.

(3) A cost accountant with thorough knowledge and experience.

(4) An engineer (mechanical/electrical/chemical).

(5) A computer specialist.

(6) A physicist.

(7) A psychologist.

Operations Research Teams that are properly set up can take up a numbers of projects. The following are the different stages of an OR project:-

(1) Formulation of the problem in clear-cut terms.

(2) The constructions of a model that is considered as the most suitable and appropriate.

(3) Finding all possible solutions.

(4) Experimentations with the model so as to evaluate the best possible solution.

(5) Applications of the model.

In short, an Operations Research Team observes phenomena, experiments, defines and uses different techniques and measures for finding the relationships between factors. For instance, the relationship between selling effort and sales.

To mentions a few, some of the common problem with which OR teams are usually confronted, are of the following type(s).

Problem 1

To provide management with the relative costs of the inventories that are necessary to guard against running out of stocks more often once (say) in ten order periods, that is, to provide management with 90 per cent security against running out of stock.

Problem 2

To provide a manufacturer of certain food products, a rational basis for setting up promotional campaigns of new products for the purpose of realising maximum profits by means of a greater degree of market penetrations in a situation of stiff competition.

Problem 3

To find the cheapest scheme for sending a given number of ships from ports to some others, when the cost of sending one ship from any of the ports to any other is known.

Operations Research Teams very often use the technique of 'Linear Programming' in tackling problems relating to the allocation of resources in an optimal way. 'Linear Programming' is a mathematical technique which involves the solution of linear equations. In other words, Linear Programming is essentially a technique that is concerned with either minimizing or maximizing a linear expression of non-negative variables subject to linear constraints.

1.13 IMPORTANCE OF OPERATIONS RESEARCH TECHNIQUES

(a) Linear Programming suggests methods of running a business as efficiently as possible and maximising profits subject to certain conditions imposed by the technology of the process, the maintenance of good industrial relations and so on. But sometimes, in practical situations, the mathematical problem is likely to become rather complicated and even tax the resources of an electronic computer. It is therefore unwise to think that the theory of Linear Programming can be helpful to every industry and firm.

According to M.G. Kendall – 'In its more limited aspects, Linear Programming is a mathematical subject, not a statistical one. But in practice it often becomes highly statistical. First of all because a great deal of the raw data is statistical and only a statistician can tell whether it is worthwhile using elaborate analytical techniques on them, and

secondly, because we may have to use statistical methods to solve the purely mathematical problems.'

Commenting on Linear Programming, G. Morton writes – 'First, it does not substitute the technician and mathematician for the economist. It is the economic who pose the problems arising from the general interdependence of economic activities. More importantly, Linear Programming does not enable one to forecast what will happen or to estimate the parameters of economic behavior. It is concerned with what to do in order to achieve specified objectives optimally if the evaluations of products is given. It applies equally to individual units and to systems of units when there is agreement on, or enforcement of, this evaluation.'

On the whole, we can conclude that since Linear Programming is mainly concerned with the problem of allocating resources in an optimal way, its use in commercial enterprises can never be underestimated.

(b) Techniques of Linear Programming can be advantageously used by OR teams in handling a number of other problems relating to :-

(1) Transportation

(2) Locations of new plants for production

(3) Locations of warehouses

(4) Optimizing the use of scarce resources

(5) Formulations of purchase policy

(6) Division of work, etc.

(c) When manufactured goods are to be transported from the plants to warehouses or certain destinations, then the OR objective is to find the best possible way so as minimize the cost of transportations. This requirement can be met using certain methods. These methods are (i) The North–West Corner Method (ii) The Least Cost Method and (iii) Vogels Approximations Method.

Other problems that can be solved by OR techniques consists of: Games Theory Problem, Simulation Problem, CPM & PERT, Inventory Control Problem, Replacement Problem etc.

Besides, there are many other types of problems which can be tackled by the use of appropriate techniques of Operations Research.

1.14 LIMITATIONS OF OPERATIONS RESEARCH TECHNIQUES

Even though OR has innumerable advantages, we should not hasten to conclude that OR always guarantees a sure success formula to the management. Therefore, in conclusion, we may ponder over the following words of Prof. Patrick Rivett of Sussex University U.K. "Since OR is a research activity, it is acquainted with failure. There is no guarantee of success to the manager who buys an OR study. Naturally, the OR scientist selects his areas of work in a way which he hopes will solve the problems, but there will still be a level of failure, which is nothing to be ashamed of only the incompetent scientist restricts his choice of a problem to the trivial and so succeeds every time. The moral for the manager is to look for problem areas in which OR is likely to be of use, to consider some questions

which he should be prepared to answer at the beginning of the study, and third to be aware of and achieve the conditions under which a study should be undertaken."

EXERCISES

1. Discuss the statement: Statistics is both a science and an art.
2. Explain the relationship between statistics and some other important sciences.
3. "Statistics are the straw out of which I, like every other economist, have to make bricks."

   -Alfred Marshall.

   Explain in the light of the above observation the relation between economics and statistics. How far is it correct to say that the science of economics is becoming statistical in its methods?
4. Describe briefly the scope and utility of statistics in the field of trade and commerce.
5. Discuss the meaning and scope of statistics, bringing out its importance, particularly in the field of trade and commerce.
6. Explain the uses and limitations of statistics.
7. "It is never safe to take published statistics at their face value without knowing their meanings and limitations and it is always necessary to criticize the arguments that can be based on them."

   -A.L. Bowley.

   Explain this statement.
8. Discuss the importance of statistics in the fields of economics, business and commerce.
9. "Statistics are aggregates of facts, affected to a marked extent by a multiplicity of causes, numerically expressed, enumerated or estimated according to reasonable standards of accuracy, collected in a systematic manner for predetermined purpose and placed in relations to each other."

   Discuss the above statement.
10. Write an essay on "Statistics in the service of trade and commerce."
11. Define statistics and show how it can help in spreading knowledge, the establishment of a sound business and the formulations of a plant for national economic development.
12. Comment on following definitions of statistics:

    "Statistics is the science of averages."

    "Statistics is the science of estimates and probabilities."
13. Write an essay on the importance of statistics in a planned economy.
14. "There is hardly any field which does not fall within the scope of statistics," says an author. Corroborate this statement.
15. Discuss the importance of the study of statistics and show how it can help the extension of scientific knowledge, the establishment of a sound business and the introduction of social and political reforms."
16. Comment on the following: "Statistics is always concerned with the mass phenomena and never with a single observation."
17. "Statistics helps business by its employment as a tool of industrial research and as an important factor in scientific research." Elucidate.

18. "The science of statistics is a most useful servant but only of great value to those who understand its proper use." **W.I. King.**

    Comment on the above statement.

19. Describe briefly the use of statistics in various spheres of human activity.

20. "Statistics only furnishes a tool, necessary though imperfect, which is dangerous in the hands of those who do know its uses and deficiencies." Discuss the above statement.

21. "Statistics touches everybody and touches life at many points. It both a science and an art." Explain this statement with suitable examples.

22. "Statistics are like the clay of which you can make a god or a devil as you please"

    Discuss.

23. "There are three kinds of lies: Lies, damned lies and statistics" Explain this statement with reference to the limitations of statistics.

24. "The science of statistics is a most useful servant but only of great value to those who understand its proper use" Discuss.

25. "It is sometimes said that statistics are used the way a drunk uses a lamppost for support rather than for illumination" Discuss.

26. Explain the meaning and purpose of OR.

27. Give a brief account of the historical background relating to origin and development of OR Techniques.

28. Describe the main characteristics of OR.

29. Write an explanatory note on the scope and tools of OR as applicable to business and industry.

30. Explain the use if OR techniques in the decision making process.

31. Describe some of the important categories of mathematical models in OR.

32. Write an explanatory note on some of the definition of OR.

33. Discuss the following statement "Operations Research is the art of giving bad answers to problems which otherwise have worse answers." (T.L. Saaty)

34. Discuss the importance of OR techniques.

35. Explain the limitations of OR techniques.

36. Explain some of the problems that fall within the scope of OR.

37. Discuss the following statements:

    (a) OR is an applied science

    (b) OR is an experimental science

    (c) Or is the science of decision making

38. State any two definitions of OR and with reference to those definition mention some important features of OR.

39. Discuss the statement "OR is an aid for the executive in making his decisions by providing him the needed quantitative information based on the scientific methods of analysis." (C. Kittel)

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