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Nandikotkur Road, Venkayapalli, Kurnool – 518452

Department of Mechanical Engineering

Bridge Course
On
Operations Research

G.PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY
Pasupula (V), Nandikotkur Road, Venkayapalli, Kurnool

Department of Mechanical Engineering

BRIDGE COURSE FOR THE SUBJECT "OPERATIONS RESEARCH"

Class: IV - IB.Tech-I Sem – Mechanical Engineering

Faculty in-charge: A.SREEKANTH

Applied mathematics:

Applied mathematics is a branch of mathematics that deals with mathematical methods that find use in science, engineering, business, computer science, and industry. Thus, applied mathematics is a combination of mathematical science and specialized knowledge. The term "applied mathematics" also describes the professional specialty in which mathematicians work on practical problems by formulating and studying mathematical models. In the past, practical applications have motivated the development of mathematical theories, which then became the subject of study in pure mathematics where abstract concepts are studied for their own sake. The activity of applied mathematics is thus intimately connected with research in pure mathematics.

Mathematical model:

A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical modelling. A model may help to explain a system and to study the effects of different components, and to make predictions about behaviour.

Elements of a mathematical model:

Mathematical models can take many forms, including dynamical systems, statistical models, differential equations, or game theoretic models. These and other types of models can overlap, with a given model involving a variety of abstract structures. In general, mathematical models may include logical models. In many cases, the quality of a scientific field depends on how well the mathematical models developed on the theoretical side agree with results of repeatable experiments. Lack of agreement between theoretical mathematical models and experimental measurements often leads to important advances as better theories are developed.

In the physical sciences, the traditional mathematical model contains four major elements. These are

Governing equations:

The governing equations of a mathematical model describe how the values of the unknown variables (i.e. the dependent variables) will change. The change of the value of a variable with respect to time may be explicit, in that a governing equation includes a derivative with respect to time, or implicit, such as when a governing equation has velocity or flux as an unknown variable.

Defining equations:

In physics, defining equations are equations that define new quantities in terms of base quantities. This article uses the current SI system of units, not natural or characteristic units.

Constitutive equations:

In physics and engineering, a constitutive equation or constitutive relation is a relation between two physical quantities (especially kinetic quantities as related to kinematic quantities) that is specific to a material or substance, and approximates the response of that material to external stimuli, usually as applied fields or forces.

Constraints:

In mathematics, a constraint is a condition of an optimization problem that the solution must satisfy. There are several types of constraints—primarily equality constraints, inequality constraints, and integer constraints. The set of candidate solutions that satisfy all constraints is called the feasible set.

Mathematical optimization:

In the simplest case, an optimization problem consists of maximizing or minimizing a real function by systematically choosing input values from within an allowed set and computing the value of the function. The generalization of optimization theory and techniques to other formulations comprises a large area of applied mathematics. More generally, optimization includes finding "best available" values of some objective function given a defined domain (or input), including a variety of different types of objective functions and different types of domains.

Classifications:

Mathematical models are usually composed of relationships and variables. Relationships can be described by operators, such as algebraic operators, functions, differential operators, etc. Variables are abstractions of system parameters of interest, that can be quantified. Several classification criteria can be used for mathematical models according to their structure:

Linear vs. nonlinear:

If all the operators in a mathematical model exhibit linearity, the resulting mathematical model is defined as linear. A model is considered to be nonlinear otherwise. The definition of linearity and nonlinearity is dependent on context, and linear models may have nonlinear expressions in them. For example, in a statistical linear model, it is assumed that a relationship is linear in the parameters, but it may be nonlinear in the predictor variables.

Static vs. dynamic:

A dynamic model accounts for time-dependent changes in the state of the system, while a static (or steady-state) model calculates the system in equilibrium, and thus is time-invariant Dynamic models typically are represented by differential equations or difference equations.

Explicit vs. implicit:

If all of the input parameters of the overall model are known, and the output parameters can be calculated by a finite series of computations, the model is said to be explicit. But sometimes it is the output parameters which are known, and the corresponding inputs must be solved for by an iterative procedure, such as Newton's method (if the model is linear) or Broyden's method (if non-linear). In such a case the model is said to be implicit.

Discrete vs. continuous:

A discrete model treats objects as discrete, such as the particles in a molecular model or the states in a statistical model; while a continuous model represents the objects in a continuous manner, such as the velocity field of fluid in pipe flows, temperatures and stresses in a solid, and electric field that applies continuously over the entire model due to a point charge.

Deterministic vs. probabilistic (stochastic):

A deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables; therefore, a deterministic model always performs the same way for a given set of initial conditions. Conversely, in a stochastic model—usually called a "statistical model"—randomness is present, and variable states are not described by unique values, but rather by probability distributions.

MEANING AND DEFINATION OF OPERATIONS RESEARCH:

OR has been defined in various ways and it is perhaps too early to define it in some authoritative way. However given below are a few opinions about the definition of OR which have been changed along-with the development of the subject.

"OR is a scientific method of providing executive departments with a quantitative basis for decision regarding the operations under their control"

"OR is a scientific method of providing executives with any analytical and objective basis for decisions"

"OR is the application of scientific methods, techniques and tools to problems involving the operations of systems so as to provide those in control of the operations with optimum solutions to the problem".

Nature of operation Research:

Operation research can be considered as being the application of scientific method by interdisciplinary teams to problems involving the control of organized systems so as to provide solutions which best serves the purposes of the organization as a whole. Different characteristics constitution the nature of operation research can be discussed below

1) Inter disciplinary team approach:

Operation research has the characteristics that it is done by a team of scientists drawn from various disciplines such as mathematics, statistics, economics, engineering, physics, etc. It is essentially an interdisciplinary team approach.

2) Systems approach:

Operation research emphasizes on the overall approach to the system. This characteristic of operation research is often referred as system orientation. The orientation is based on the observation that in the organized systems the behavior of any part ultimately has some effect on every other part.

3) Helpful in improving the quality of solution:

Operation research cannot give perfect answers or solutions to the problems, it merely gives bad answers to the problems which otherwise have worst answers. Thus operation research simply helps in improving the quality of the solution but does not result into a perfect solution.

4) Scientific method:

Operation research involves scientific and systematic attack of complex problems to arrive at the optimum solution. In other words, operation research uses techniques of scientific research. Thus operation research comprehends both aspects i.e. it includes both scientific research on the phenomena of operating systems and the associated engineering activities aimed at applying the results of research.

5) Goal oriented optimum solution:

Operation research tries to optimize a well defined function subject to given constraints and as such is concerned with the optimization theory

Scope of operation research in Management:

Operation research is a problem solving and decision making science. It is a kit of scientific and programmable rules providing the management a 'quantitative basis' for decisions regarding the operations under its control. Some of the areas of management where operation research techniques have been successfully applied are:

(1) Allocation and distribution:

- Optimal allocation of limited resources such as men, machines, materials, time and money.
- Location and size of warehouse, distribution centers, retail depots etc.
- Distribution policy.

(2) Production and facility planning:

- Selection, location and design of production plants, distribution centers and retail outlets.
- Project scheduling and allocation of resources
- Determination of the number and size of the items to be produced
- Maintenance policy and preventive maintenance.

(3) Procurement:

- What, how and when to purchase at the minimum procurement cost.
- Bidding and replacement policies
- Transportation planning and vendor analysis.

(4) Marketing:

- Product selection, timing and competitive actions.
- Selection of advertising media.
- Demand forecasts and stock levels.
- Best time to launch a new product.

(5) Finance:

- Capital requirements, cash-flow analysis
- Credit policies, credit risks etc.
- Profit plan for the company.

(6) Personnel:

- Selection of personnel, determination of retirement age and skills.
- Recruitment policies and assignment of jobs
- Wage or salary administration

Quantitative Analysis as a Frame Work for Managerial Decision:

Managerial decision-making is a process by which the management, when faced with a problem chooses a specific course of action from a set of possible options. In making a decision, a business manager attempts to choose the most effective course of action in the given circumstances in attaining the goals of the organization. The various types of decision-making situations that a manager might encounter can be listed as follows:

1. Decisions under certainty, where all facts are known fully and for sure, or under uncertainty where the event that would actually occur is not known but probabilities can be assigned to various possible occurrences.

2. Decisions for one time period only, called static decisions, or a sequence of interrelated decisions made either simultaneously or over several time periods, called dynamic decisions.

3. Decisions where the opponent is nature (digging an oil well, for example) or a rational opponent (for instance, setting the advertising strategy when the actions of competitors have to be considered.

4. These classes of decision-making situations are not mutually exclusive and a given situation would exhibit characteristics from each class. Stocking of an item for sale in a certain trade fair, for instance, illustrates a static decision-making situation where uncertainty exists and nature is the opponent.

The elements of any decision are:

1. A decision-maker, who could be an individual, group, organization, or society.

2. A set of possible actions that may be taken to solve the decision problem.

3. A set of possible states that might occur.

4. A set of consequences(pay-off) associated with various combinations of courses of action and the states that may occur and

5. The relationship between pay-off and the values of the decision-maker

In an actual decision-making situation, the definition and identification of alternatives, the states and the consequences, are most difficult, albeit not the most crucial aspects of the decision problem.

In real life, some decision-making situations are simple while others are not. Complexities in decision situations arise due to several factors. These include the complicated manner of interaction of the economic, political, technological, environmental and competitive forces in society, the limited resources of an organization, the values, risk attitudes and knowledge of the decision-makers and the like.

For example, a company's decision to introduce a new product will be influenced by such consideration as market conditions, labor rates and availability, and investment requirements and availability of funds. The decision will be of multidimensional response, including the production methodology, cost and quality of the product, price, package design, and marketing and advertising strategy. The result of the decision would conceivably affect every segment of the organization.

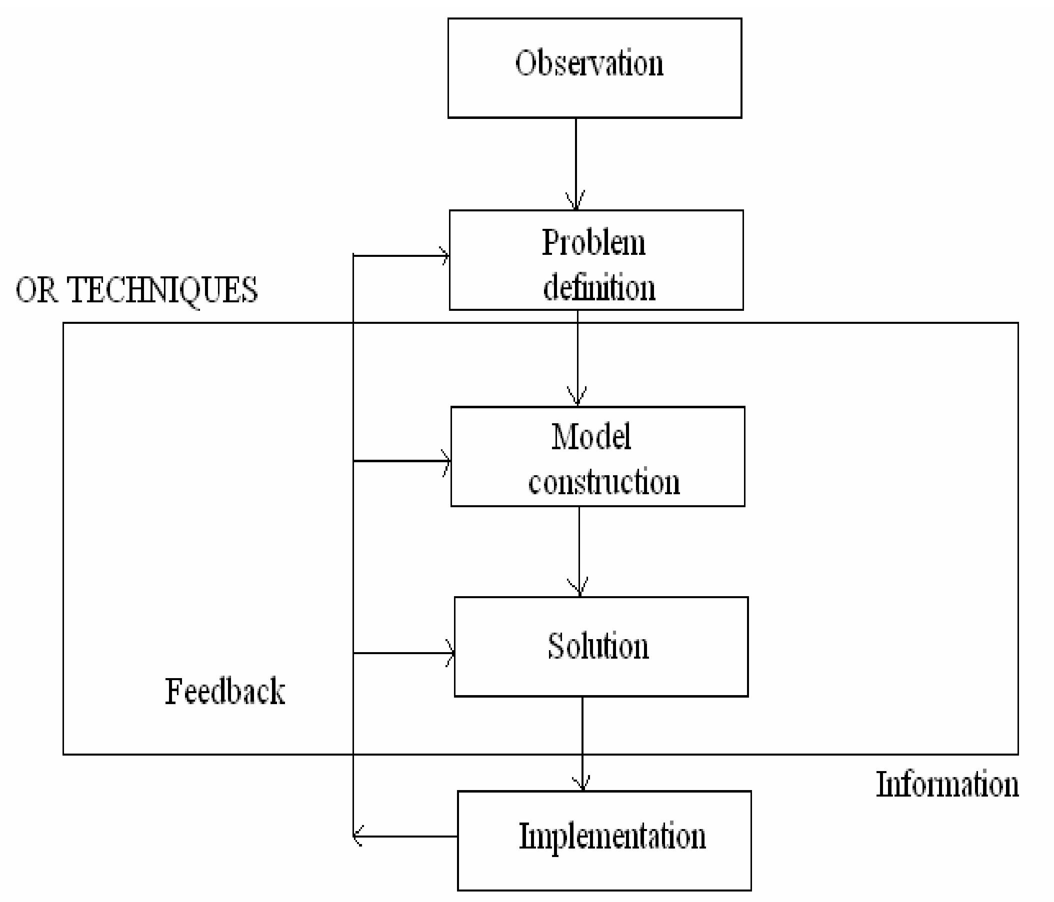
The essential idea of the quantitative approach to decision-making is that if the factors that influence the decisions can be identified and quantified, it becomes easier to resolve the complexity of the tools of quantitative analysis. In fact, a large number of business problem have been given a quantitative representation with varying degrees of success and it has led to a general approach which is variedly designated as operations research (or operational research), management science, systems analysis, decision analysis, decision science and so on. Quantitative analysis is now extended to several areas of business operations and represents probably the most effective approach to handling of some types of decision problems.

OR APPROACH TO PROBLEM SOLVING:

OR encompasses a logical systematic approach to problem solving this approach to problem solving as shown in below fig follows a generally recognized ordered set or steps:

1. Observation,
2. Definition of the problems,
3. Model construction,
4. Model solution, and
5. Implementation of solution results.

OR PROCESS:



(1) Observation

The first step in a problem solving exercises in OR is the identification of a problem that exists in the system. This requires that the system be continuously and closely observed so that problems can be identified as soon as they occur.

(2) Definition of the Problem

Once it has determined that a problem exists, it must be clearly and concisely defined. The problem definition includes the limits of the problems and the degree to which it pervades other organs of the system. A requirement of problem definition is that the goals (or objective) must be clearly defined which helps to focus attention on what the problem is.

(3) Model Construction

An OR model is an abstract representation of an existing problem situation. It can be in the form of a graph or chart, but mostly, an OR model consists of a set of mathematical relationship. In OR terminology, these are called objective function and constraints.

(4) Model Solution

Once models are constructed, they are solved using the OR techniques, presented in the next section. Actually it is difficult to separate model construction and solution in most cases, since OR technique usually applies to a specific type of model. Thus, the model type and solution method are both part of the OR technique.

(5) Implementation of Results

The results of an OR technique are information which helps in making a decision. The beauty of OR process lies in obtaining, the results which are implement able or we call it a feasible whole exercise will go waste.

APPLICATIONS OF OPERATIONS RESEARCH:

As mentioned earlier OR can be applied in every field of life. Here are few of the many fields where OR has potential application. This list is by no means comprehensive or exhaustive but definitely will provide an idea of the power of OR as a separate discipline.

Operations Research in the Public Sector:

Federal, Provincial and Local Government:

- Development of Country Structure Plans
- Manpower Planning and Career Development in Govt. Departments
- Organization of Long-Term planning groups at the National Level
- Corporate Planning in Local Government

- Allocation of Government Houses
- Estimation of Future Requirement of School/College Building
- Placing of Fire Brigade in a City
- Measuring the Effectiveness of Police
- Timetabling in Schools and Colleges for Efficient use of Space

Health:

- Management policies for 120-bed nursing units
- Optimum size of general hospitals
- Appointment systems for hospital outpatients
- Stock control for regional and area health units
- National and area planning of health services
- Manpower planning for nurses, radiographers, etc.
- Commissioning of a new general hospital
- Simulation of pathology laboratories
- Organizing an ambulance service
- Care provided by community nurses

Defense:

- Arms control and disarmament studies
- Communications network development
- Logistic support in operations
- Field experimentation
- War games and other models of battle
- Equipment procurement
- Reinforcement and redeployment problems

Operations Research in Industry & Commerce:

Finance and Investment:

- Developing the five-year plan for a food manufacturer
- Development of the pipeline
- Computer based financial planning
- Portfolio selection
- Structure for the assets of a bank
- Evaluating investment in a new plant
- Corporate planning in the chemical industry
- Financing expansion of a small firm

Production:

- Production scheduling in a steel works
- Meeting peak demands for electricity
- Minimization of costs of power station maintenance
- Scheduling newsprint deliveries
- Stock levels of steel plate
- Meeting seasonal demands for products
- Blending scrap metals
- Stock policy for a paint manufacturer
- Allowing for yarn breaks in spinning
- Meeting customer requirements for carpets
- Planning a quarry's output
- Optimum layout for belt coal transport in a colliery

Marketing:

- Launching a new product
- Advertising effectiveness and cost
- Planning sales territories

- Measurement of consumer loyalty
- Buyer-seller behavior
- Advertising research and media scheduling
- Most profitable retail brand mix
- Developing customer service policies
- Pricing policies for confectionery

Personnel:

- Personnel shift planning
- Manpower planning
- Manpower for an assembly line
- Effects of flexible working hours

Distribution:

- Distribution of Products.
- Returnable bottles: how many?
- Refinery crude tank capacity
- Depot location of pharmaceutical products
- Trucking policy for dairy products
- Distribution of newspapers to newsagents

OR in Transport:

Rail:

- Rail freight management
- Required fleet size of locomotives and rolling stock
- Forecasting passenger traffic
- Planning reconstruction of main-line termini
- Introduction of freightliners

Road:

- Designing urban road networks
- Forecasts of car ownership
- Implementation of bus lanes
- Re-routing bus services
- Purchasing and maintenance of buses
- Introduction of flat-fare buses
- Bus services in rural areas
- Preparation of crew rosters

Air:

- Planning the introduction of Boeing 737/Airbus 300
- Allocation of aircraft and crew to routes
- Location of Islamabad Airport
- Karachi-Lahore - Islamabad - Peshawer: aircraft requirements

Sea:

- Potential traffic for new container services
- Shipbuilding requirement in the 1990's
- Optimum ship size for given routes
- Construction and management of a container terminal

QUANTITATIVE SPECIALISTS AND THE MANAGER:

Manager gets thing done and with people in an organization. Managers do planning, organizing, staffing, directing and controlling. He plays different roles such as interpersonal role, informational role and divisional role. Management functions and roles don't exist opposite to each other but these are two ways of interpreting what manager also. In order to perform various management functions effectively, managers must possess certain skills. These skills are technical, human and conceptual skills.

Quantitative specialists perform calculations and apply mathematical and statistical tools and methods to process the raw information's are processed and presented in orderly manner, manager uses these data to make logical decisions.

RELATIONSHIP BETWEEN THE QUANTITATIVE SPECIALISTS AND THE MANAGER:

There exists a strong bond between Quantitative specialists and the manager. Quantitative specialists provide valuable data to manager, on the basis of these data manager takes important decisions for the organization. Information is processed by Quantitative specialists. He applies various books and techniques to process the raw information. Manager uses these data for important decision making. Quantitative techniques provide round fundamental base for decision making. Quantitative specialists and manager both work for the benefit of the organization. Every important decision is based on conclusion drawn by Quantitative specialists. Although, manager is the person who makes the decision but Quantitative specialists is the person who supports the manager in the decision-making process. Quantitative specialists are concerned with only mathematical and statistical tools and techniques, while manager is the overall head of the organization. Manager performs execution of operations and managing the company.

Finally, we can say that there exists a strong bond between Quantitative specialists and manager. Position of both of them is very vital for the organization.