UNIT – I

COURSE OBJECTIVES:

1. To impart fundamental knowledge and skill sets required in the Industrial Management and Engineering profession, which include the ability to apply basic knowledge of mathematics, probability and statistics, and the domain knowledge of Industrial Management and Engineering
2. To produce graduates with the ability to adopt a system approach to design, develop, implement and innovate integrated systems that include people, materials, information, equipment and energy.
3. To enable students to understand the interactions between engineering, business, technological and environmental spheres in the modern society.
4. To enable students to understand their role as engineers and their impact to society at the national and global context.

SYLLABUS: UNIT – I

INTRODUCTION: Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, quantitative tools of IE and productivity measurement. Concepts of management, importance, functions of management, scientific management, Taylor's principles, theory X and theory Y, Fayol's principles of management.

INTRODUCTION:

DEFINITION OF INDUSTRIAL ENGINEERING:

The concept of industrial engineering has great significance in the industrial organizations. Today every organization is giving much importance to this concept. Industrial engineering may be defined as the "engineering approach to the detailed analysis of the use and cost of the resources of an organization". The main resources are men, money, material, equipment and machinery. These are valuable productive resources.

The industrial engineer carries out such analysis in order to achieve the objectives and policies of the organization. He is associated with organization structure administrative techniques human problems and at the same time he understands the relationship between efficiency and consent.

F.W.TAYLOR is considered as the father of the modern industrial engineering. He put forth his ideas on scientific management and work measurement in 1881 and as a result industrial engineer came out as a formal technique in USA. In 1885 frank b gilbert introduced motion study which is very much related with the work measurement technique of F.W.TAYLOR other pioneers in the field were L.H.GONT, EMERSON, CARL BRATH, and SHEWHART. Etc..,

HISTORY/EVOLUTION OF INDUSTRIAL ENGINEERING MANAGEMENT:

The origins of industrial engineering can be traced back to many different sources. **Fredrick Winslow Taylor (F.W. Taylor)** is most often considered as the father of **industrial engineering** even though all his ideas where not original. Some of the preceding influences may have been Adam Smith's treatise *The Wealth of Nations*, published in 1776, Thomas Malthus's Essay *on Population*, published in 1798, David Ricardo's *Principles of Political Economy and Taxation*, published in 1817, and John Stuart Mill's *Principles of Political Economy*, published in 1848. [1] All of these works provided Classical Liberal explanations for the successes and limitations of the Industrial Revolution. Adam Smith was an economist as were most of his contemporaries at the time. "Economic Science" is the phrase to describe this field in England prior to American industrialization. The amount of influence this literature had on Taylor is unknown.

Another major contributor to the field and **precursor to Taylor was Charles W. Babbage. Babbage** was mathematics professor at Cambridge University. One of his major contributions to the field was his book On the Economy of Machinery and Manufacturers in 1832. In this book he discusses many different topics dealing with manufacturing, a few of which will be extremely familiar to an IE. Babbage discusses the idea of the learning curve, the division of task and how learning is affected, and the effect of learning on the generation of waste. He also was very interested in different methods of wage administration and even suggested profit sharing as a viable approach. Charles Babbage was the first person to suggest building a mechanical computer, "analytical calculating machine" as he called it, for the purpose of solving complex mathematical problems. An idea that is far beyond the technology of his time but later proves to be a valuable concept to the modern IE.

In the United States during the latter part of the nineteenth century more developments where being made that would lead to the formalization of industrial engineering. Henry R. Towne stressed the economic aspect of an engineer's job. How was the engineer going to improve the bottom line for the company? Towne belonged to the **American Society of Mechanical Engineers (ASME)** as did many other early American pioneers in this new field. It was to the ASME that Towne expressed the need to develop a field focused on manufacturing systems. The IE handbook says the, "ASME was the breeding ground for industrial engineering."[2] Towne along with Fredrick A. Halsey worked on developing and presenting wage incentive plans to the ASME. It was out of these meetings that the Halsey premium plan of wage payment developed. The purpose of his plan was to increase the productivity of workers without negatively affecting the cost of production. The plan also suggested that some of the gains be shared with the employees as an incentive to keep it going. This is one early example of one profit sharing plan.

Henry L. Gantt also belonged to the ASME and was interested in selection of workers and their training. He, like Towne and Halsey, would present papers to the ASME on topics such as cost, selection of workers, training, good incentive plans, and scheduling of work. He is the originator of the Gantt chart, currently the most popular chart used in scheduling of work. Today however, the Gantt chart is coupled with statistics to

make more accurate predictions. Other types of charts that have developed out of the early scheduling efforts are the Program Evaluation and Review Technique (PERT) and Critical Path Mapping (CPM).

No history of industrial engineering would be complete without mentioning **Fredrick Winslow Taylor**. Taylor is probably the best known of the pioneers in industrial engineering. He used the ASME as present his ideas on the organization of work by management. He coined the term "scientific management" to describe the methods he developed through empirical studies. His work, like others, covered topics such as the organization of work by management, worker selection, training, and additional compensation for those individuals that could meet the standard as developed by the company through his methods. The Taylor method of Scientific Management had far reaching effects on the industrial revolution, in America, and abroad.

During the 1960s, and after, Universities began to adopt operation research techniques and add them to the curriculum for the Industrial Engineering Degree. Now for the first time the methods of industrial engineering could rest on an analytical foundation, instead of the old method of empiricism. New developments in mathematics for optimization as well as new methods of advanced statistical analysis helped to fill in the holes once left by the purely theoretical approach. However, problems where extremely large and complex to and until the digital computer was developed processing this kind of information was almost impossible.

APPLICATIONS OF INDUSTRIAL ENGINEERING:

Before 1940 industrial engineering was mainly applied to manufacturing industries for improving methods of productivity, to develop work standards, to formulate production control and wage policies. But after 1940 the use of industrial engineering also spread to non-manufacturing activities also. Such as construction, transportation firm, airline operation and maintenance, public utilities, government and military operations. etc.., in an industry besides the production other groups utilizing industrial engineering concepts are marketing, finance, purchasing, industrial relations etc..,

ROLE OF INDUSTRIAL ENGINEER IN THE ORGANIZATION:

An industrial engineer plays a vital role in the organization. No, organization can successfully run without industrial engineer. We can analyze the role of industrial engineer in the following manner.

1. **Advisor/Consultant:** Available to others for interpretation of data, review etc.
2. **Advocate/Activist:** Promote actively process or approach
3. **Analyst:** Separate a whole into parts and examine them to explore for insight and characteristics.
4. **Boundary Spanner:** Bridge the information/interest gap between industrial engineering and user.
5. **Motivator:** Provide stimulus and skill availability to a group or individual
6. **Decision Maker:** Select a preference from among many alternatives for topic of concern.
7. **Designer/Planner:** Produce the solution specific topic.
8. **Expert:** Provide a high level of knowledge, skill, & experience on a specific topic.
9. **Coordinator & Integrator**

10. **Innovator/Inventor:** Seek to produce a creative or advanced technology solution
11. **Measure:** Obtain data and facts about existing conditions
12. **Project Manager:** Operate, Supervise and evaluate projects.
13. **Trainer/Educator:** Skills and knowledge of an industrial engineer
14. **Data gather.**
15. **Negotiator.**
16. **Optimum use of resources:** His role is very significant in utilizing the existing productive resources in most efficient and effective manner. He always tries to minimize the wastage of resources. Optimum utilization of resources is essential to achieve best results in production, marketing, HR. etc..,
17. **Minimizing the cost of resources and production:** He always tries to minimize the cost of production with different techniques and methods. No, organizations can success without getting maximum production with minimum cost.
18. **Production, Planning and Control:** Designing plans to achieve continuous production without any interruption is the main function of industrial engineer. He designs production plans and also control production mechanism.
19. **Product, Design and Development:** He has perfect knowledge about design and development. Product design and development play a vital role in getting profits. He always try to design best product and also try to develop it. Generally he designs products according to the attitude and interest of customers.
20. **Inspection and Quality Control:** He frequently inspects the product and gives guide lines to the production department. He always tries to produce quality products. No organization cans success without producing quality products. He gives suggestions and guide lines to quality products.
21. **Plant Layout and Location:** He designs plant layout to achieve best results in each and every aspect. The success of an organization is also based on its plant layout and location.
22. **Work Study:** He designs work study reports and implement in the organization. He gives suggestions and guidelines to workers and employees. If there is any difficulty or problem. He rectifies it immediately.
23. **Method Study:** He designs production methods and implement them in the plant. No organization can successfully run without method study. He always tries to introduce new methods in production.
24. **Work Measurement and Work Standards:** He measures the work done by workers and employees with different techniques and methods. On the basis of work measurement wages and salaries are fixed. He also prepares work standards.

DEFINITION OF MANAGEMENT:

Management is a universal phenomenon. We can see it in every walk of life. Ex: house management, college management, hotel management etc.., now it is a rapidly growing discipline. Management is the process of getting things done with others as per firm's objectives. No, business firm or organizations can success without management. Several management experts have defined the term management in different ways. They are:

- **HENRY FAYOL** the father of management defines the term management as "to manage is to forecast and plan, to organize, to command, to coordinate and control."

- **HERALD KOONTZ** defines the term management as "management is the technique of getting things done through and with the people in formally organized groups."
- **F.W.TAYLOR** defines management as "management is the art of knowing what you want to do in the cheapest and best way."
- **PETER F DRUCKER** defines management as "management is concerned with the systematic organization of economic resources and its task is to make these resources productive."

NATURE OF MANAGEMENT:

We can analyse the nature or characteristics of management in the following manner:

1. **Management is a process:** It is a process. It includes a number of aspects such as planning, organizing, directing, controlling, coordinating, staffing, motivating... etc.
2. **Management is a continuous process:** It is a continuous process. As long as universe exists it will exists. It is eternal or immortal.
3. **Management is an activity:** It is an activity. It includes decision making activities, informational activities and interpersonal activities. Etc.., which are essential for the success of an organization.
4. **Management is a discipline:** It is a separate branch of study like computers, mathematics, statistics... Etc. it is one of the important branch to carryout business very successfully.
5. **Management is dynamic:** Its nature is dynamic. It formulates several new policies according to time being. It designs new policies and methods according to changing business needs or business environment. Today a lot of research is going on management.
6. **Management is complex:** Its nature is complex. It has close relation with several subjects. It is interdependent. It depends on mathematics, social, economics... etc. there are several theories and principles formulated by management experts. Its functions are complex.
7. **Management is a group activity:** It is a group activity. It is associated with different people in the organization. It has several levels. Ex: - higher level, middle level, lower level.
8. **Management is both science and an art:** Management combines the features of both science and art. It is a scientific art. Science is a systematic body of knowledge relating to a specific field of study and contains journal facts that explain a phenomenon. Art is basically concerned with understanding the way a particular task is achieved in the best possible manner. While science provides the principles, the application of these principles is the subject matter of art.
9. **Management is an integrating process:** It is an integrating process. It integrates men, money, material for performing various operations and accomplishing the stated goals.
10. **Management is a profession:** It is a profession because some of its established principles are being applied in practice.

11. **Management is goal oriented:** It has certain goals and objectives. It always try to achieve these goals. It's a main goal is over all development of the society.

OBJECTIVES OF MANAGEMENT:

The main objectives of management are:

1. Achieving best results with minimum efforts.
2. To improve the efficiency of factors of production and productive resources.
3. To improve the condition of employers and employee's.
4. To provide equal opportunity to different sections of the people in the society.
5. To improve the standard of living of people.
6. To provide social justice.
7. To increase national output and national income.
8. To minimize cost of production and maximize profits.
9. To provide better quality products to consumers.
10. To promote industrial peace.
11. To achieve greater production in industrial organizations.
12. To promote knowledge and skill among human resources.
13. To meat social needs.

IMPORTANCE OF MANAGEMENT:

It has great significance in industrial organizations. Its role is very prominent in production, marketing, finance, human resources, research and development. No, industrial organization can service without management. We can analyze its importance in the following manner:

I. **Determination of objectives:**

Its role is very significant in determining objectives. Every business firm has certain objectives. It helps in determining these objectives in most efficient and effective way. Generally business is a risky affair. It includes a number of problems and uncertainties. These problems arise on various aspects. No, business organizations can success without over coming these problems.

II. **Achieving the objectives:**

Management plays a vital role in achieving the objectives of business firms. Every business firm has certain objectives as far as production, marketing, finance, HR... Etc. is concerned. Management guides the managerial personnel in each and every aspect. They can achieve the objectives very easily with the help of management principles.

III. **Optimum utilization of existing resources:**

Management plays a vital role in utilizing the existing productive resources in optimum manner. They can use the productive resources in a best way. Generally productive resources are very scare management helps in minimizing wastage of productive resources. Ex: - men, money, material, machinery etc. are valuable productive resources. Optimum utilization of these resources is essential.

IV. **Social benefits:**

Management play a vital role in social or societal development. It is a part and parcel of the society. Its main aim is to develop the society. It helps to supply quality products to the public. It has greater social responsibility. It must meet the needs of the society. It must satisfy the consumer needs, shareholder's needs, government needs... Etc. it makes the society more dynamic and result oriented.

V. **Establishers sound organization:**

Management helps in establishing a sound organization. It creates good relationship between superiors and subordinates. Sound organizations are essential to achieve greater production without efficient management. It is not possible to achieve greater production.

VI. **Meeting challengers:**

Management helps in meeting a number of challengers faced in industrial organizations with efficient management they can face several problems very easily and try to overcome from such problems. Several problems arises in the field of production, marketing, finance, HR related aspects.

VII. **National economic development:**

Management plays a significant role in national economic development. It helps to achieve rapid economic development and growth. It helps to increase national output national income, total saving, total investment, total demand and total supply.

VIII. **Smooth running of business:**

Management plays a vital role in smooth running of business organizations. Business organizations can run very smoothly with help of management. It helps in minimizing strikes and lockouts, retrenchments dispute's. It helps to produce goods and services continuously. It establishes good relations between management and labour force. Management promotes industrial peace.

FUNCTIONS OF MANAGEMENT:

Management is a universal phenomena. We can see it in every walk of life. It is an integral part of society. The process of getting things done through others as per firm's objectives is known as management. Henry fayol the father of management classified management functions into planning, organizing, commanding, coordinating and controlling.

Gullick and **Urwick** have described the management functions as POSDCORB. Here P stands for planning, O stands for organizing, S-staffing, D-directing, CO –coordination, R-reporting, B-budgeting.

However the functions of management can be divided into six categories:

A. Planning
B. Organizing
C. Staffing
D. Directing
E. Coordinating
F. Controlling

A. Planning: This is one of the important functions of management. Planning is a mental process requiring foresight and sound judgment. Planning is the process of deciding in advance what to do, when to do, where to do and how the results are to be evaluated. It is nothing but taking action in advance and deciding today what is to be done tomorrow. Efficient planning is essential to achieve the organizational goals in most efficient and effective manner. No, organizations can success without planning.

B. Organizing: It is the process of establishing relationships among the members of the organization. This relationship is created in the form of authority and responsibility. It is an important activity by which management brings together the manpower and material resources for the accomplishing of free determined goals. It also involves creating job positions at various levels and establishing mutual relationships between them. No, organizations can success without organizing.

C. Staffing: It refers to placing of right persons at the right job at the right time. It involves recruitment, selection, training etc., It involves training managers and other employee's to improve their capabilities and preparing subordinates for the future as well as ensuring their personal development and growth. While performing the staffing function managers prepare reports on the performance of their subordinates and make recommendations regarding their promotion. No, organizations can success without staffing.

D. Directing: It is the process of guiding the subordinates towards achieving the organizational goals. Generally managers issue day to day instructions and guide lines to the subordinates. Managers have to communicate decisions and instructions to the subordinates. It is nothing but giving guidance to the subordinates. It is concerned with the activating of the members of the organization for the accomplishment of the organizational goals. No, organization can successfully run without directing.

E. Coordinating: It is the process of integrating the activities of different units and organization to accomplish the organizational goals efficiently. The purpose of coordination is to ensure that the goals of units and subunits are pursued in harmony with each other keeping in view the goals of the organization. Coordination is needed at all levels of management due to the interdependent nature of activities assigned to various departments and units.

F. Controlling: It is the process of seeing whether the activities have been performed in conformity with the plains. It helps the management to get its policies implemented and to take corrective actions if

performance is not in accordance with the planned objectives. No, organization can successfully run without controlling.

DIFFERENCES BETWEEN PRODUCTION MANAGEMENT AND INDUSTRIAL ENGINEERING:

Production engineering basically deals with the manufacturing process based engineering such as fabrication, machining, casting, forging etc.

Industrial engineering has only one motive, I.e. to increase productivity (output to input) of an industry by designing techniques developed from scientific methods of engineering. It includes Time and motion study where a qualitative and quantitative evaluation of a work is carried out.

S.No.	BASIS	PRODUCTION MANAGEMENT	INDUSTRIAL ENGINEERING
1	Definition	Production management refers to planning, Co-ordinating and controlling the resources of production department which is engaged in production of a specific product or service	Industrial Engineering refers to the process of designing, developing and installing integrated systems to thee variable resources of productive systems.
2	Objective	The main objective of Production Management is to optimal utilise the resources so as to produce desired output.	The main objective of Industrial Engineering is to design such a integrated systems which ensures improvement in productivity.
3	Functions	It functions include selection of materials, Methods, Machinery, and Equipment, Estimating, Loading and scheduling, Routing, Despatching, Expediting or follow up, Inspection and evaluation.	It function include advising, advocating, analysing, decision making, co-ordinating and integrating, data gathering and measuring.
4	Application	It can be applied to only production activities	It can be applied to manufacturing as well as non-manufacturing activities.
5	Operation	Production managers operates the designed systems.	Industrial Engineer's designs the system but, does not operate them regularly.
6	Area of Focus	It focus on individuals to make them aware of using various tools, techniques and concepts effectively.	It focus on systems to make them highly productive.
7	Example	It gives training to individual in operating drilling system.	It supports engineers in designing drilling system.

QUANTITATIVE TOOLS OF IE AND PRODUCTIVITY MEASUREMENT:

The tools and techniques of industrial engineering aim at improving the productivity of the organization by optimum utilization of organization's resources, i.e. men, materials and machines.

The various tools and techniques of industrial engineering are:

i. **Method study**: To establish a standard method of performing a job or an operation after thorough analysis of the jobs and to establish the layout of production facilities to have an uniform flow of material without back tracking.
ii. **Time study:** This is a technique used to establish a standard time for a job or for an operation
iii. **Motion economy:** This is used to analyze the motions employed by the operators to do the work. The principles of motion economy and motion analysis are very useful in mass production or for short cycle repetitive jobs.
iv. **Financial and non-financial incentives:** These helps to evolve at a rational compensation for the efforts of the workers.
v. **Value analysis:** It ensures that no unnecessary costs are built into the product and it tries to provide the required functions at the minimum cost. Hence, helps to enhance the worth of the product.
vi. **Production, planning and control:** This includes the planning for the resources (like men, materials and machines), proper scheduling and controlling production activities to ensure the right quantity, quality of the product at predetermined time and pre-established cost.
vii. **Inventory control:** To find the economic lot size and the recorder levels for the items so that the items should be made available to the production at the right time and quantity to avoid stock out situation and with minimum capital lock-up.
viii. **Job evaluation:** This is a technique which is used to determine the relative worth of jobs of the organization to aid in matching jobs and personnel and to arrive at sound wage policy.
ix. **Material handling analysis:** To scientifically analyze the movement of materials through various departments to eliminate unnecessary movement to enhance of material handling.
x. **Ergonomics (Human engineering):** It is concerned with study of relationship between man and his working conditions to minimize mental and physical stress. It is concerned with man-machine systems.
xi. **System analysis:** System analysis is the study of various sub-systems and elements that make a system, their interdependencies in order to design, modify and improve them to achieve greater efficiency and effectiveness.
xii. **Operation research techniques:** These techniques aid to arrive at the optimal solutions to the problems based on the set objective and constraints imposed on the problems.

The techniques that are more often used are:

a. Linear programming problems
b. Simulation models
c. Queuing models

d. Network analysis (CPM & PERT)

e. Assignment, sequencing and transportation models.

PRODUCTIVITY CONCEPTS AND MEASURES:

PRODUCTIVITY:

Productivity is the ratio between output and input. It is quantitative relationship between what we produce and what we have spent to produce.

Hence, $$Productive = \frac{OUTPUT}{INPUT}$$

Productivity is, above all, a **state of mind-set**. It is an attitude that seeks the continuous improvement of what exist. It is a conviction that **one can do better today than yesterday, and that tomorrow will be better than today.**

It is the driving force or dynamism behind developing and upgrading the quality of industrial activities.

IMPORTANCE OF PRODUCTIVITY:

- Productivity increases output.
- High productivity results in lower cost per unit of output resulting in higher levels of profit for a business.
- Higher profits for the firm will mean more funds available for its expansion, new business ventures and community support.
- It may also wish to pass on the benefits of lower costs to consumers in the form of lower prices.

CONCEPTUAL ASPECTS OF PRODUCTIVITY:

Productivity is an objective concept, which can be measured, ideally against a universal standard. As such, organizations can monitor productivity for strategic reasons such as corporate planning, organization improvement, or comparison to competitors. It can also be used for tactical reasons such as project control or controlling performance to budget.

Productivity is useful as a relative measure of actual output of production compared to the actual input of resources, measured across time or against common entities. As output increases for a level of input, or as the amount of input decreases for a constant level of output, an increase in productivity occurs. Therefore, a "productivity measure" describes how well the resources of an organization are being used to produce output.

Productivity is often confused with efficiency. Efficiency is generally seen as the ratio of the time needed to perform a task to some predetermined standard time. However, doing unnecessary work efficiently is not exactly being productive. It would be more correct to interpret productivity as a measure of effectiveness (doing the right thing efficiently).

EXPRESSIONS OF PRODUCTIVITY:

Productivity is usually expressed in one of three forms: partial-factor productivity, multifactor productivity, and total-factor productivity.

I. **Partial-Factor Productivity:** The standard definition of productivity is actually what is known as a partial-factor measure of productivity, in the sense that it only considers a single input in the ratio. The formula then for partial-factor productivity would be the ratio of total output to a single input. Managers generally utilize partial-factor productivity measures because the data is readily available. Labour based hours (generally, readily available information) is a frequently used input variable in the equation. Other partial-factor measure options could appear as output/machine, output/capital, output/energy, or output/inventory. Multifactor Productivity. A multifactor productivity measure utilizes more than a single factor, for example, both labour and capital. Hence,

II. **Multifactor productivity:** Multifactor productivity is the ratio of total output to a subset of inputs which for example could be labour and materials. Obviously the input factors must be measured in the same units, for example pounds sterling or standard hours.

III. **Total-Factor Productivity:** A broader gauge of productivity, total-factor productivity is measured by combining the effects of all the resources used in the production of goods and services (labor, capital, raw material, energy, etc.) and dividing it into the output.

Total output must be expressed in the same unit of measure and total input must be expressed in the same unit of measure. However, total output and total input can be expressed in different units of measurement. Resources are often converted to pounds sterling or standard hours so that a single figure can be used as an aggregate measure of total input or output.

Total productivity ratios reflect simultaneous changes in outputs and inputs. As such, total productivity ratios provide the most inclusive type of index for measuring productivity and may be preferred in making comparisons of productivity. However, they do not show the interaction between each input and output separately and are thus too broad to be used as a tool for improving specific areas.

Total-factor productivity is a measure favoured by the Japanese, whereas labour productivity is the measure most favoured in the UK and the United States.

DIFFERENCE BETWEEN PRODUCTION AND PRODUCTIVITY:

	Production	Productivity
Definition	It is defined as the act of manufacturing goods for their use or sale.	It is defined as the rate of which goods are produced.
Use	It is the actual process of conversion.	It is the utilization of resources to form goods
Work done	It is the amount of work done or manufactured that is the output.	It is the amount of work one gets for a certain spending cost.
Measurement	It is the measure of produced goods.	It is the measure of efficiency.

PRODUCTIVITY MEASURES:

It has been said that the challenge of productivity has become a challenge of measurement. Productivity is difficult to measure and stems from the fact that inputs and outputs are not only difficult to define but are also difficult to quantify.

One common problem with productivity measures is the inability to consider quality changes (e.g., output per hour might increase, but it may cause the defect rate to increase significantly). It is easier to conceive of outputs as tangible units such as number of orders picked, but other factors such as quality should be considered.

Experts have cited a need for a measurement program that gives an equal weight to quality as well as quantity (productivity). If quality is included in the ratio, output may have to be defined as something like the number of defect-free units of production or the number of units that meet customer expectations or requirements.

USE OF PRODUCTIVITY MEASURES:

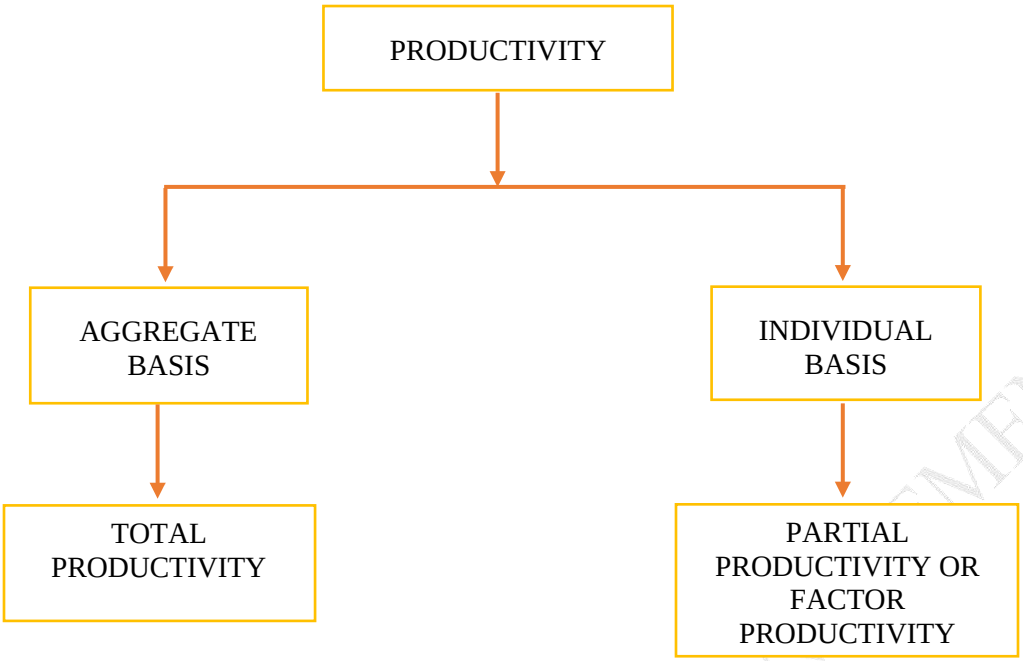
Productivity is a required tool in evaluating and monitoring the performance of an organisation. When directed at specific issues and problems, productivity measures can be very powerful. In essence, productivity measures are the yardsticks of effective resource use.

Managers are concerned with productivity as it relates to making improvements in their firm. Proper use of productivity measures can give the manager an indication of how to improve productivity: either increase the numerator of the measure, decrease the denominator, or both.

Managers are also concerned with how productivity measures relate to competitiveness. If two firms have the same level of output, but one requires less input thanks to a higher level of productivity, that firm will be able to reduce prices and protect or increase its market share or charge the same price as competitors and enjoy a larger profit margin.

Within a time period, productivity measures can be used to compare the firm's performance against industry-wide data, compare its performance with similar firms and competitors, compare performance among different departments within the firm, or compare the performance of the firm or individual departments within the firm with the measures obtained at an earlier time (i.e., is performance improving or decreasing over time?

TECHNIQUES FOR MEASUREMENT OF PRODUCTIVITY:



AGGREGATE BASIS: On aggregate basis, output is compared with all inputs taken (added) together. This is called as Total Productivity.

Hence, $$Total\ Productivity\ Index = \frac{TOTAL\ OUTPUT}{TOTAL\ INPUT}$$

Where,

Total Output = Total production of goods and services and

Total Input = Labor + Material + Capital + Energy.

This index measures the productivity of the entire organization with use of all resources. It is a way of evaluating efficiency of entire plant or firm.

Example:

10,000 Units Produced

Sold for Rs10/unit

500 labor hours

Labor rate: Rs.9/hr

Cost of raw material: Rs.30,000

Overhead: Rs. 15,500

Example: Total Productivity

$$TP = \frac{Output}{Labour + Materials + Overhead}$$

$$TP = \frac{(10000\ units) \times (Rs.10)}{(500) \times (Rs.9) + (Rs30,000) + (Rs.15,500)}$$

T P = 2.0

INDIVIDUAL BASIS: On individual basis, output is compared with any one of the input factor and this is called as Partial Productivity or Factor Productivity.

Factor productivity or partial productivity indices are of following types:

I. **Labor productivity**
II. **Material productivity**
III. **Machine Productivity**
IV. **Capital productivity**

LABOR PRODUCTIVITY: Labor productivity is simply defined as the ratio of Total output to the Labour input i.e.

$$Labour\ Productivity = \frac{Total\ Output}{Lobour\ Input}$$

Labor productivity depends upon how labors are utilized.

Labor productivity can be higher or lower depending on factors like availability of work load, material, working tools, availability of power, work efficiency, level of motivation, level of training, level of working condition (comfortable or poor) etc.

Example

- 10,000 Units Produced
- Sold for Rs. 10/unit
- 500 labor hours
- Labor rate: Rs. 9/hr

What is the labor productivity?

- 10,000 units / 500hrs = 20 units/hr
- (10,000 units * Rs. 10/unit) / 500hrs = Rs. 200/hr
- 10,000 units / (500hrs *Rs. 9/hr) = 2.2 unit/Rs.
- (10,000 units * Rs. 10/unit) / (500hrs * Rs. 9/hr) = 22.22
- The last one is unit-less

MATERIAL PRODUCTIVITY: Material productivity plays an important role in cost of production.

$$Material\ Productivity = \frac{Total\ Output}{Material\ Input}$$ or

$$M\ P = \frac{Number\ of\ units\ Produced}{Total\ material\ cost}$$

Material productivity depends upon how material is effectively utilized in its conversion into finished product.

Material productivity can be increased by using skilled workers, adequate machine tools, good design of product etc.

MACHINE PRODUCTIVITY: Production system converts raw material into finished product through mechanical or chemical process with the help of machines and equipment's.

$$Machine\ Productivity = \frac{Total\ Output}{Machine\ Input} \quad \text{or}$$

$$M\ P = \frac{Output\ in\ standard\ hours}{Actual\ machine\ hours}$$

Machine productivity depends upon availability of raw material, power, skill of workers, machine layout etc.

CAPITAL PRODUCTIVITY: For any production set-up, facilities of machines, tools, land etc. are required which are assets of organization. Capital is needed for such assets.

$$Capital\ Productivity = \frac{Total\ Output}{Capital\ Input} \quad \text{or}$$

$$C\ P = \frac{Total\ Output}{Capital\ Employed}$$

Capital productivity depends on how effectively assets are utilized.

Productivity is an overall measure of the ability to produce a good or service. Productivity may also be defined as an index that measures output (goods and services) relative to the input (labour, materials, energy, etc., used to produce the output). There are two major ways to increase productivity: increase the numerator (output) or decrease the denominator (input). A similar effect would be seen if both input and output increased with output increasing faster than input; or if both input and output decreased with input decreasing faster than output. A productivity ratio can be computed for a single operation, a department, a facility, an organization, or even an entire country.

FACTORS AFFECTING PRODUCTIVITY:

There is quite a variety of factors that can affect productivity, these include:

- ✓ Capital investments in technology and equipment
- ✓ Capital investments in facilities
- ✓ Economies of scale
- ✓ Workforce knowledge and skill resulting from training and experience
- ✓ Technological changes
- ✓ Work methods and procedures
- ✓ Systems

- ✓ Quality and reliability of suppliers
- ✓ Quality of management
- ✓ Legislative and regulatory environment

IMPROVING PRODUCTIVITY:

Improvement may be realized through improved methods, investment in machinery and technology, improved quality, and improvement techniques and philosophies such as just-in-time, total quality management, lean production, supply chain management principles, and theory of constraints.

A firm or facility may undertake a number of key steps toward improving productivity:

- Develop productivity measures for all operations; measurement is the first step in managing and controlling an organization.
- Look at the system as a whole in deciding which operations are most critical, it is overall productivity that is important.
- Develop methods for achieving productivity improvement, such as soliciting ideas from workers (perhaps organizing teams of workers), studying how other firms have increased productivity, and re-examining the way work is done.
- Establish reasonable goals for improvement.
- Provide management support and encouragement.
- Measure improvements and publicize them.

However, organizations must be careful not to focus solely on productivity as the driver for the organization. Organizations must consider overall competitive ability. The Company's success is also influenced and achieved through other factors including quality, cycle time, reasonable lead time, innovation, and factors directed at improving customer service and satisfaction.

ADVANTAGES OF PRODUCTIVITY:

- ➢ It emphasizes the efficient utilization of all the factors of production which are scarce universally.
- ➢ It attempts to eliminate wastage.
- ➢ It facilitates the comparison of the performance of a company to its competitors or related firms, in terms of aggregate results and of major components of performance.
- ➢ It enables the management to control the performance of the company by identifying the comparative benefits raising out of the use of different inputs.

SCIENTIFIC MANAGEMENT MEANING:

Application of scientific principles and theories to management is called scientific management. According to Taylor scientific management means knowing exactly what you want men to do and seeing that they do

it in the best way and the cheapest way. The scientific methods consist of research and experiments, collection of data, analysis of data and formulation of certain new principles.

PRINCIPLES OF SCIENTIFIC MANAGEMENT:

Principles of scientific management propounded by Taylor are:

1. Science, Not Rule of Thumb.
2. Harmony, Not Discord.
3. Mental Revolution.
4. Cooperation, Not Individualism
5. Development of each and every person to his or her greatest efficiency and prosperity.

1. **Science, Not Rule of Thumb:** In order to increase organisational efficiency, the 'Rule of Thumb' method should be substituted by the methods developed through scientific analysis of work.

   Rule of Thumb means decisions taken by manager as per their personal judgments. According to Taylor, even a small production activity like loading iron sheets into box cars can be scientifically planned. This will help in saving time as well as human energy. Decisions should be based on scientific enquiry with cause and effect relationships.

   This principle is concerned with selecting the best way of performing a job through the application of scientific analysis and not by intuition or hit and trial methods.

   The work assigned to any employee should be observed and analyzed with respect to each element or part thereof and the time involved therein so as to decide the best way of performing that the work and to determine the standard output for same.

2. **Harmony, Not Discord:** Taylor emphasized that there should be complete harmony between the workers and the management since if there is any conflict between the two, it will not be beneficial either for the workers or the management.

   Both the management and the workers should realize the importance of each other. In order to achieve this state, Taylor suggested complete mental revolution on the part of both management and workers.

   It means that there should be complete change in the attitude and outlook of workers and management towards each other. It should always be kept in mind that prosperity for an employer cannot exist for a long time unless it is accompanied by the prosperity of the employees of that organisation and vice versa.

   It becomes possible by

   (a) Sharing a part of surplus with workers
   (b) Training of employees,
   (c) Division of work
   (d) Team spirit
   (e) Positive attitude
   (f) Sense of discipline
   (g) Sincerity etc.,

Management should always be ready to share the gains of the company with the workers and the latter should provide their full cooperation and hard work for achieving organizational goals. Group action with mutual-trust and understanding should be perfect understanding the focus of working.

This principle requires that there should be perfect understanding between the management and workers and both should feel that they are part of same family. It helps to produce synergy effect since both management and workers work in unison.

For example, in most of the Japanese companies, paternalistic style of management is in practice and there is complete openness between workers and the management. Usually, workers don't go on the strike but, if at all they do so, they just wear a black badge and work even more than the normal hours just to impress upon the management that their focus is on their demands as well as organisational objectives.

3. **Mental Revolution:**

The technique of Mental Revolution involves a change in the attitude of workers and management towards each other. Both should realize the importance of each other and should work with full cooperation. Management as well as the workers should aim to increase the profits of the organisation.

For this the workers should put in their best efforts so that the company makes profit and on the other hand management should share part of profits with the workers. Thus, mental revolution requires a complete change in the outlook of both management and workers. There should be a spirit of togetherness between workers and management.

4. **Cooperation, Not Individualism:**

This principle is an extension of principle of 'Harmony, not discord' and lays stress on mutual cooperation between workers and the management. Cooperation, mutual confidence, sense of goodwill should prevail among both, managers as well as workers. The intention is to replace internal competition with cooperation.

Both 'Management' and 'Workers' should realize the importance of each other. Workers should be considered as part of management and should be allowed to take part in decision making process of the management. Management should always welcome their suggestions and should also reward them if their suggestions prove to be beneficial for the organisation viz. reduction of costs or increase in production etc.

At the same time, workers should also resist from going on strike or making unnecessary demands from management. Workers should be treated as integral part of organisation and all important decisions should be taken after due consultation with workers. Both of them should visualize themselves as two pillars whose soundness alone can ensure achievement of common goals of the organisation.

Taylor also suggested that there should be proper division of work and responsibility between the two. Management should always guide, encourage and help the workers.

5. **Development of each and every person to his or her greatest efficiency and prosperity:**

Efficiency of any organisation also depends on the skills and capabilities of its employees to a great extent. Thus, providing training to the workers was considered essential in order to learn the best method developed through the use of scientific approach. To attain the efficiency, steps should be taken right from the process of selection of employees. Employees should be scientifically selected.

The work assigned to each employee should suit his/her physical, mental and intellectual capabilities. Efficient employees produce more to earn more. This ultimately helps to attain efficiency and prosperity for both organisation and the employees.

ELEMENTS OF SCIENTIFIC MANAGEMENT:

To bring scientific management into practice, Taylor suggested the following techniques or elements. They are:

1. **Scientific task setting:** Setting the standard task of every worker through scientific investigation
2. **Work study:** Work study means a systematic objective and critical determination of operational efficiency in an organization. It includes method study, motion study, time study, fatigue study. Etc.
3. **Rate setting:** It means determination of wages and salaries. Taylor suggested differential piece rate system. If the wages are fixed on the basis of the quantity or volume of the work done by the workers, it is called piece rate system.
4. **Planning the Task:** It refers to determination of the quantity of o/p to be produced by each and every worker in advance.
5. **Standardization:** It refers to determination of certain standards in production. In other words maintaining quantity at various levels.
6. **Scientific Selection & Training:** It refers to using scientific methods & techniques in selection & training. According to him every organization must follow scientific techniques & methods in selection & training. They have to recruit qualified efficient & experienced persons.
7. **Differential Piece Wage Plan:** It refers to payment of wages & salaries on the basis of quantity of work done by the workers & employees. This plan encourages workers to produce more output.
8. **Specialization:** It refers to division of labour Taylors suggested functional foremanship even at the shop or floor level under this system an operator or worker works under the control of eight foremen, four at the shop level & four at the office level.

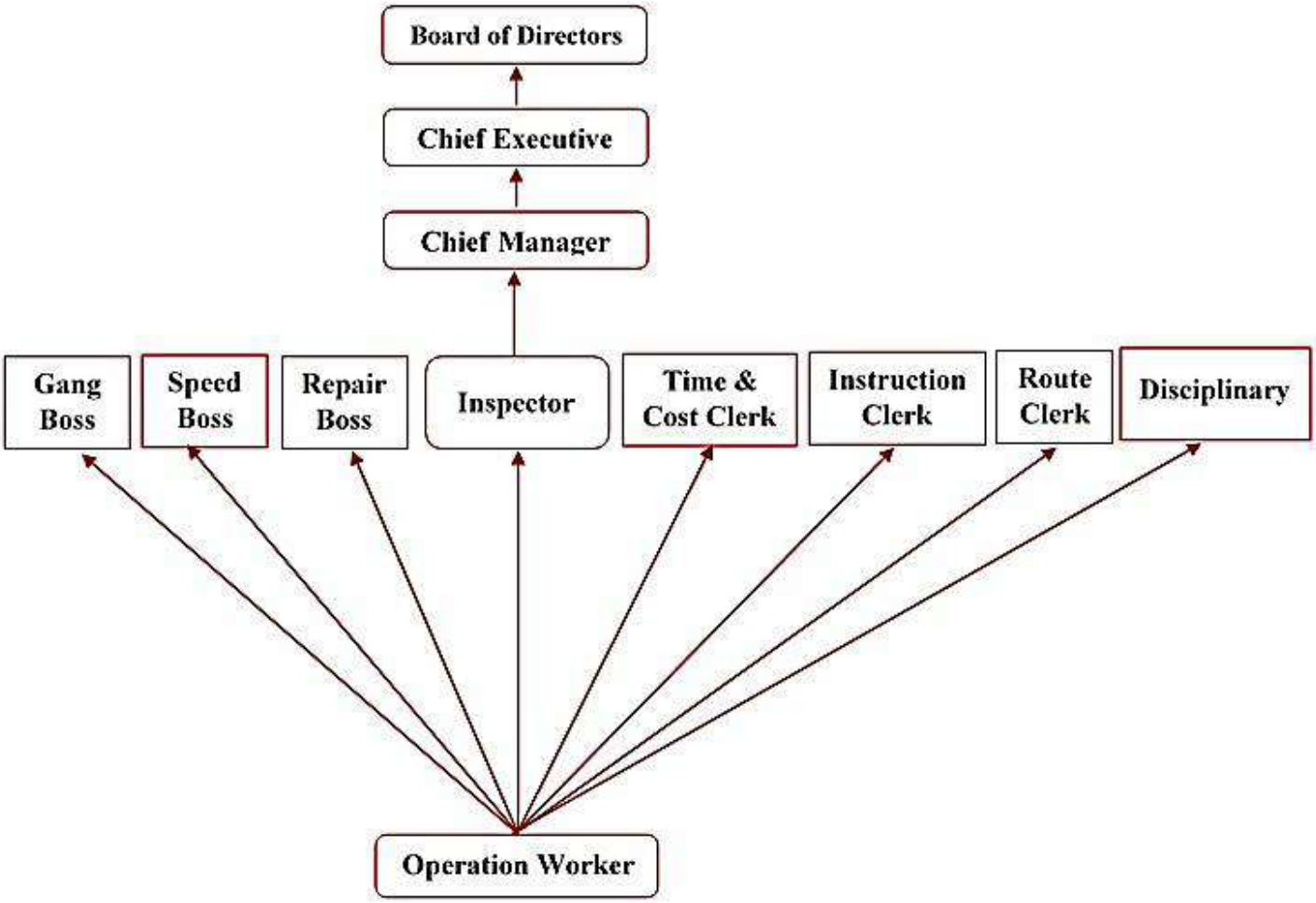
   The four foremen at shop level are

   a) Gang boss
   b) Speed boss
   c) Repair boss
   d) Inspector

   The four foremen at office level are

   a) Time & Cost Clerk
   b) Instruction Card Clerk
   c) Route Clerk
   d) Disciplinarian

Taylor's scientific theory of management can be understood with the help of following chart.



DOUGLAS MCGREGOR THEORY- X & THEORY- Y?

Douglas McGregor presented two sets of assumptions in the form of theory -X & theory- Y. To explain the nature of employees & to understand human behaviour. These two sets of assumptions are popularly called theory- X & theory -Y.

THEORY -X:

This theory is based on the following assumptions. They are

1) Employees are inherently lazy
2) They require constant guidance & support.
3) Sometimes they require even coercion & control
4) Given an opportunity they would like to avoid responsibility.
5) They do not show up any ambition but always seek security.
6) He explained all the negative features of employees in theory -X.

THEORY Y:

This theory is entirely different from theory- x. it is based on the following assumptions. They are:

1) Some employee's consider work as natural as play or rest.

2) These employees are capable of directing and controlling performance as their own. They are much committed to the objectives of the organization. They show much interest towards the objectives of the organization.
3) Higher wages and salaries makes these employee's more dynamic, committed to organization.
4) Given an opportunity they not only accept responsibility but also look for opportunities to outperform.
5) Most of them are highly imaginative creative and discipline in handling organizational issues. He explained all the positive features of employee's in theory -Y.

FREDERICK WINSLOW TAYLOR'S SCIENTIFIC MANAGEMENT:

At the outset, it must be made clear that in the world of management, there is no concept of management which might be called 'Scientific Management'; capable of universal application and commanding wide acknowledgment from scholars and practitioners of management.

What Frederick Winslow Taylor calls scientific management is typically a management philosophy pioneered and practiced by him (and his followers) according to his own ideology; and is something like 'India of My Dreams' as envisaged by Gandhiji. Accordingly, Taylor's Scientific Management is popularly called as 'Taylorism'.

INTRODUCTION TO FREDERICK WINSLOW TAYLOR AND HIS WORK:

F.W. Taylor (1856-1915) was an American, who joined Midvale Steelworks, Philadelphia (U.S.A.) as a machinist; and gradually rose to the position of the Chief Engineer-through hard work and progress. F.W. Taylor conducted his experiments in three companies viz., Midvale Steel Works, Simonds Rolling Machine and Bethlehem Steel Works.

Taylor's Scientific Managements was, in fact, a movement known as the 'Scientific Management Movement' pioneered by Taylor and carried on by his followers. The important publications of Taylor are all combined into one book titled 'Scientific Management'.

TAYLOR'S MAIN OBSERVATION:

Throughout his life career, Taylor had observed that there was excessive inefficiency in the management and functioning of industrial enterprises. In fact, the primary blame for the inefficient functioning of industrial enterprises was put by Taylor on management; for it was management who did not know what constituted a fair day's task and also the 'best way' of doing the same.

Therefore, he came out with his new concept of management, called scientific management.

SCIENTIFIC MANAGEMENT DEFINED:

Scientific management might be defined as : Scientific management involves the application of a scientific approach to managerial decision making (consisting of-collection of data, an analysis of data and basing decisions on the outcome of such analyses); and discarding at the same time, all unscientific approaches, like – rule of the thumb, a hit or miss approach and a trial and error approach.

FREDERICK WINSLOW TAYLOR DEFINED SCIENTIFIC MANAGEMENT IN THE FOLLOWING WORDS:

"Scientific Management consists in knowing what you (i.e. management) want men to do exactly; and seeing to it that they do it in the best and the cheapest manner."

PRINCIPLES OF SCIENTIFIC MANAGEMENT:

The fundamental principles, which would support the concept and practice of scientific management, are the following:

i) Science, not the rule of the thumb.

ii) Harmony, not discord.

iii) Co-operation, not individualism.

iv) Maximum production, in place of restricted production.

v) Development of each person to the greatest of his capabilities.

vi) A more equal division of responsibility between management and workers.

vii) Mental revolution on the part of management and workers.

Following is a brief comment on each of the above principles of scientific management.

i) Science, not the rule of thumb:

The basic principle of scientific management is the adoption of a scientific approach to managerial decision making; and a complete discard of all unscientific approaches, hitherto practiced by managements.

ii) Harmony, not discord:

Harmony refers to the unity of action; while discord refers to differences in approach.

iii) Co-operation, not individualism:

Co-operation refers to working, on the part of people, towards the attainment of group objectives; while regarding their individual objectives-as subordinate to the general interest.

iv) Maximum production, in place of restricted production:

In Taylor's view the most dangerous evil of the industrial system was a deliberate restriction of output. As a means of promoting the prosperity of workers, management and society, this principle of scientific management emphasizes on maximising production and not deliberately restricting it.

v) Development of each person to the greatest of his capabilities:

Management must endeavour to develop people to the greatest of their capabilities to ensure maximum prosperity for both-employees and employers.

vi) A more equal division of responsibility between management and workers:

The principle of scientific management recommends a separation of planning from execution. According to this principle, management must be concerned with the planning of work; and workers with the execution of plans.

vii) Mental revolution on the part of management and workers:

According to Taylor, scientific management, in its essence, involves a complete mental revolution on the part of both sides to industry viz. workers and management (representing employers).

In fact, this principle of scientific management is the most fundamental one ensuring success of it. It is like the foundation on which the building of scientific management must be erected.

AN OUTLINE STRUCTURE OF TAYLOR'S SCIENTIFIC MANAGEMENT:

Though Taylor's work and practice of it is quite comprehensive and detailed; yet the major aspects of work done by him could be summarized into the following outline structure:

1. Determination of a fair day's task for each worker through scientific methods (including the best way of doing a job).
2. Scientific selection and training of workers.
3. Standardisation of raw materials, tools and working conditions.
4. Functional foremanship.
5. Differential piece-rate system of wage-payment.

Following is a brief account of the above aspects of scientific management:

1. **Determination of fair day's task for each worker through scientific methods (including the best way of doing a job):**

   For determining a fair day's task for each worker, Taylor recommended the use of scientific methods involving the conduct of the following three types of work studies, viz.,

   a) Time study
   b) Motion study
   c) Fatigue study

   The following points are not worthy in this context:

   - An average worker (or representative worker) is first selected for conducting the above work-studies. In case otherwise, the standards of work fixed would be either too high or too low.
   - The above three work-studies (i.e. time, motion and fatigue studies) are to be considered together to arrive at a fair day's task.

2. **Scientific selection and training of workers:**

This aspect of scientific management is, in fact, the staffing angle of it. The workers, under scientific management, must be properly selected by adhering to a carefully- designed selection procedure. Further, selected workers must be imparted training in best methods of performing a job.

3. Standardisation of raw materials, tools and working conditions:

By standardisation, Taylor implies two varieties of standardisation:

- Raw materials, tools, machines and other facilities of work must be of a reasonably good quality; so that the quality of production is reasonable.
- Another variety of standardization which Taylor refers to is uniformity in providing work-facilities and work conditions to all workers, doing a similar type of job.

4. Functional Foremanship:

The scheme of functional foremanship recommended by Taylor is, in fact, an introduction of managerial specialisation-at the shop-level. In Taylor's view, instead of a single foreman performing all the aspects of the foremanship task, there must be a number of foremen-each concerned with only a particular aspect of foremanship.

Each foreman, being a specialist in performance of his role, is a functional foreman. Hence, the nomenclature of the scheme as 'functional foremanship'.

In the context of the scheme of functional foremanship, Taylor compares workers with students in a school class-room; where a student is imparted teaching in a particular subject by a specialized teacher of that subject – instead of a single teacher teaching all the subject to students.

In the scheme of functional foremanship recommended by Taylor, there is a provision for eight foremen of the following types:

(i) Route Clerk: The route clerk is a foreman who would lay down the route (or journey) of raw materials from the raw-material stage to the finished product stage as passing through different processes and machines.

(ii) Instructions Card Clerk: The instructions card clerk is a foreman who would determine the detailed instructions for handling a job; and prepare a card containing such instructions.

(iii) Time and Cost-Clerk: The time and cost clerk is a foreman who would record the time taken by a worker in completing a job; and would also compile the cost of doing that job.

(iv) Shop Disciplinarian: The shop disciplinarian would look after the maintenance of discipline in the workshop and deal with cases of absenteeism, misbehaviour and other aspects of indiscipline.

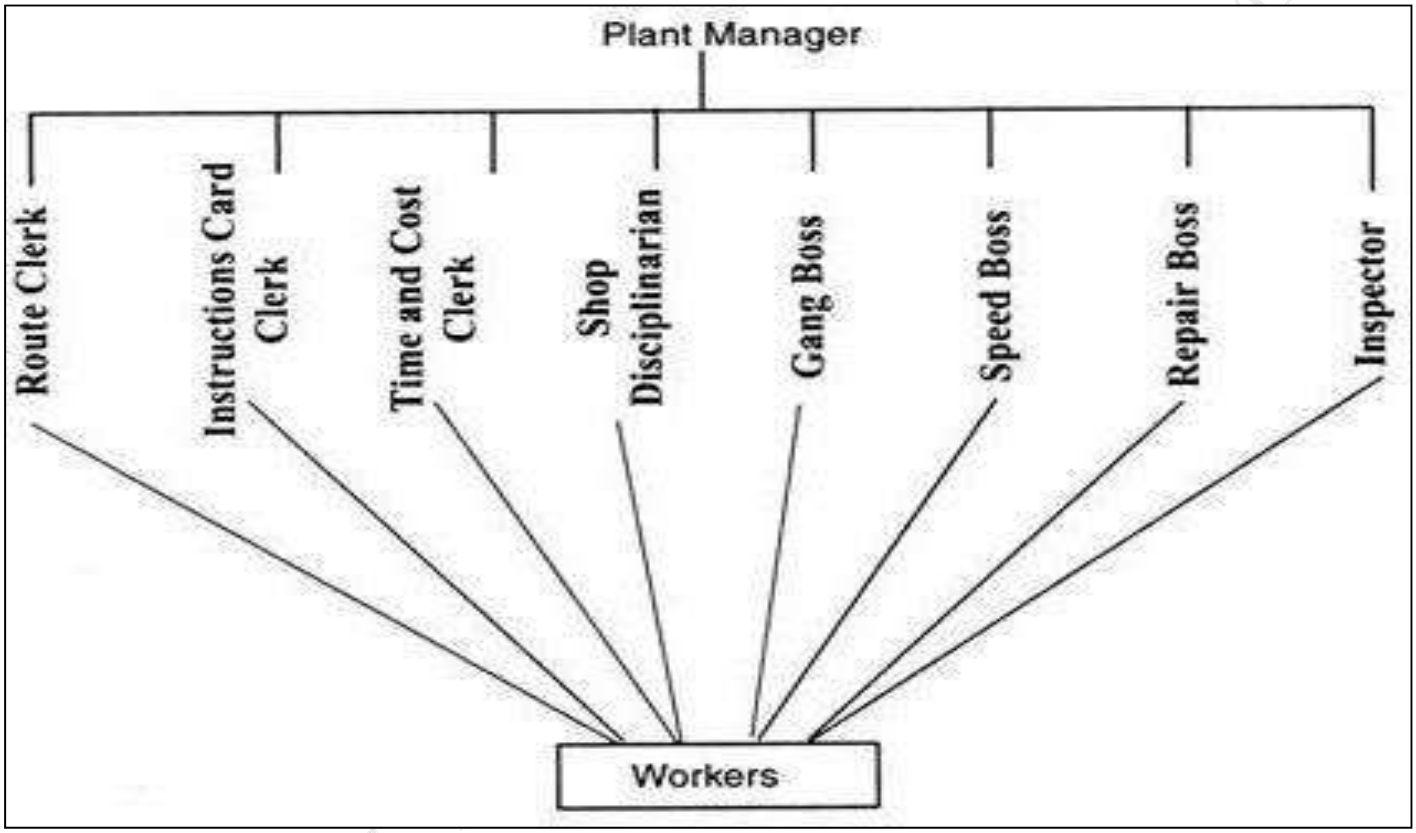
(v) Gang Boss: The gang boss is the supervisor proper. He would see to it that all work-facilities are made available to workers and they start their work as per the instructions imparted to them.

(vi) Speed Boss: The speed boss is a foreman who would determine the optimum speed at which machines are to be operated; so that both-over speeding and under-speeding of machines are avoided. In this way, less depreciation is caused to machines; industrial accidents are averted and quality of production is also maintained.

(vii) Repair Boss: The repair boss is a foreman, who would look after and take care of the repairs and maintenance of machines.

(viii) Inspector: Inspector is a foreman who would look after the quality of production.

The following chart illustrates the functioning of the scheme of the functional foremanship:



5. Differential piece-rate system of wage-payment:

In order to motivate workers positively as also negatively to produce the standard output, Taylor devised a scheme of wage payment, known as the 'Differential piece-rate system of wage-payment.'

The inherent features of this scheme are:

(i) A standard output for each worker is determined in advance through scientific work studies.

(ii) Two rates of wage-payment (based on piece rate system) are established-

a. A higher rate per unit of output; and

b. A lower rate per unit of output.

(iii) Workers who produce the standard output or exceed the standard are paid according to the higher rate for all the units produced by them. Those workers who are unable to come up to the standard are paid according to the lower rate for all the units produced by them.

Let us take an example to illustrate the working of this system of wage payment. Suppose the standard output is 25 units; and the two rate of wage payment are – Rs.2 per unit (the higher rate) and Rs. 1.80 p. per unit (the lower rate).

Now, if a worker produces 25 units or more; he would be paid on total production done by him according to Rs.2 per unit. If, on the other hand, a worker produces only 24 units (taking the extreme case); he would be paid on all the 24 units produced by him, according to the lower rate i.e. Rs. 1.80 p per unit.

In the latter case, the worker is not only suffering a shortfall of payment on one unit produced less by him as against the standard of 25 units; but also suffering a shortfall of payment of 20 p. per unit on all the 24 units produced by him. Thus there is a severe penalty for the inefficient worker in being paid according to the lower rate on total production done by him.

MERITS OF SCIENTIFIC MANAGEMENT:

Some of the merits of scientific management are:

i. **More production and higher profits:** Scientific management makes for a more systematized way of managing-enabling employers (of course, through their managements) to have more production at the minimum cost; and ultimately reap higher profits.

ii. **Job satisfaction:** Under scientific management, a standardized work-environment (raw materials, tools, machines, conditions of work etc.) is provided to workers which would enable them to derive what is known as 'job satisfaction' – the biggest happiness for workers, according to the psychologist.

iii. **Personality development:** As one of the basic principles of scientific management is the 'development of each person to the greatest of his capabilities' workers get an opportunity, under scientific management, to develop themselves fully according to their potential.

iv. **Higher standard of living:** Scientific management is oriented towards maximum production; which would lead to more of consumption of goods on the part of people, in the society. This naturally, would mean an increase in the standard of living of people.

CRITICISM OF SCIENTIFIC MANAGEMENT:

Scientific management has come in for a severe criticism at the hands of the employer, the worker, the psychologist and the theoretician.

Some of the major points of attack on scientific management from different quarters are as follows:

i. **Unsuitable for the small employers:** Scientific management is wholly unsuitable for the small employers. Techniques like time, and motion studies, introduction of managerial specialization, etc. are too costly to be afforded to by the small employers.

ii. **Unemployment:** Scientific management leads to unemployment of workers; especially when mechanical devices are introduced to replace manual labour.

iii. **Retarding human development:** According to psychologist, scientific management aims efficiency at the cost of initiative. It totally takes away initiative from workers. In fact, under scientific management, workers are reduced to the status of machines; totally deprived of the thinking function.

ADVANTAGES OF SCIENTIFIC MANAGEMENT:

The following are the principal advantages of scientific management.

1. It provides trained minds for achieving higher degree of excellence in all branches of shop management.
2. It completely revolutionizes and improves layout, routing, scheduling, purchasing, stores keeping and accounting.
3. It aims to standardize the materials, tools, equipment and methods of work.
4. It offers facilities for specialization and division of labour.
5. It replaces the old system of management rule of thumb method and introduces new and scientific methods.
6. Careful time and motion studies eradicate delays, avoid bodily strains of the workers, eliminate wastage and thereby contribute to the efficiency of the workers and ensures waste less utilization of the resources.
7. It seeks to introduce a mental revolution in the ideas of both the employer and employee and assures co-operation of the labour force.
8. It seeks a reduction in the cost of production through increased output. This would help the organization to complete on a better footing and thereby enlarge the market.
9. The workers are in a position to get higher wages. This removes most of the causes for industrial disputes and unrest. Further, enhanced earnings also lead to higher standard of living of the workers Thus, scientific management does justice to various sections of the society such as producers, workers and the consumers.

DISADVANTAGES OF SCIENTIFIC MANAGEMENT:

In spite of the illuminating advantages referred above, the concept of Scientific Management has become a subject of burning criticism. Not only the workers, but also the employees and even industrial psychologists are questioning the validity of Scientific Management. We shall now briefly examine the criticisms levelled by these three parties under distinct headings:

DISADVANTAGES OF SCIENTIFIC MANAGEMENT FROM EMPLOYERS POINT OF VIEW:

Most of the employers are highly reluctant to adopt the principles of Scientific Management. They object the introduction of the principles of Scientific Management on the following grounds.

1. **High Costs:** It is a costly affair. A thorough overhauling of the existing plant and organizational structure is highly expensive. Time and motion studies as well as other improvements involve a heavy initial outlay of capital.
2. **Unsuitable for Small Firms:** Since the introduction of Scientific Management involves huge expenditure, small firms cannot afford to adopt it.
3. **Response from the workers:** The system can be successfully implemented only with the heart felt co-operation of the workers. If they fail to respond favourably, the system shall fail to bring the desired results.

DISADVANTAGES OF SCIENTIFIC MANAGEMENT FROM EMPLOYEES POINT OF VIEW:

The principal objections raised by the organized trade unions and the labour class are as follows:

1. **Loss of Individual's Initiative:** The leading objection to Scientific Management that comes from workers is that it leads to excessive job standardization. Under Scientific Management, methods of work are all standardized and instructions are given to the workers by the foreman. The workers are supposed to perform the work in the same style and carry out the instructions given by the foreman. This tends to destroy the individual worker's initiative, renders their skill useless, makes their work monotonous and converts them into automatic machines.
2. **Speeding up of Workers:** Scientific Management aims to speed up the workers, not consideration of their health and well-being. Mere speeding up of the workers without corresponding structural changes in the organization and working conditions shall not lead to higher output but create only harmful mental conditions in the workers.
3. **Autocratic Control of Functional Bosses:** Another severe objection raised against the Scientific Management is that it is undemocratic in nature as it gives absolute control to the functional bosses and lessens the interest and responsibility of the workers. The workers ought to obey the orders and the instructions given by the superior or the foreman.
4. **Creation of Unemployment:** The critics of scientific management also argue that scientific management creates unemployment and hits the workers hard as a consequence of the adoption of labour saving devices both in the machinery and in the arrangement of work.
5. **Unfairness:** Another objection is that it tends to be unfair to the workers. A lion's share of the additional profit arising out of increased efficiency does not go to the workers but goes to the coffers of the employer. It is also stated that the introduction of Scientific Management, has the effect of lowering the wages of the workers. But it is not true because Taylor himself has proved with statistical data that workmen in the scientifically managed companies received wages 35% higher than those doing the same job in other companies.
6. **Monotony:** Separation of planning function from that of doing, and excessive specialization, reduces the work to a mere routine. It would create monotony. Monotony refers to a mental state of slackness, inefficiency and a loss of interest in the job.

7. **Opposed by Trade Unions:** Under Scientific Management, the dominant issues of wages and working conditions are scientifically determined. This aspect embraces the workers and tries to introduce ideal conditions of work. Such a thing will naturally upset the very basis of the trade union movement.
8. **Absence of Non-financial Incentives:** Absence of non-financial incentives is another drawback of the Scientific Management. Non-financial incentives can do many things more than what financial incentives can do.

DISADVANTAGES OF SCIENTIFIC MANAGEMENT FROM INDUSTRIAL PSYCHOLOGISTS POINT OF VIEW:

The objections raised by the industrial psychologists are mainly based on the human element involved in the management. They view that Taylor's principles are too impersonal and undermine the importance of the human factor. The following are the main objections raised by them.

1. Workers are human beings and cannot be standardized in the same way as machines and materials. Any attempt to standardize their activities will not result in a success.
2. The Scientific Management places emphasis on discovering the one best way of doing a work without considering the individual difference of the workers. Each human being has his own genius, abilities, style and mode. Hence, the best can be obtained only by giving scope to shape their carrier according to their carrier abilities and aptitudes.
3. Payment of wages on piece rate basis will make the workers disappointed, particularly the beginners and untrained workers.

HENRY FAYOL'S PRINCIPLE OF MANAGEMENT:

He is the French industrialist; engineer and the father of management subjected 14 principles of management for the successful running of an organization. He also identified 6 activities to be accomplished in an organization. These 6 are:

- Technical activities: - which are related to procurement of technology and its related aspects.
- Financial activities: - which are related to procurement of financial resources and its related aspects.
- Marketing activities: - which are related to buying and selling and its related aspects.
- Managerial activities: - which are related to organizing and controlling.
- Accounting activities: - which are related to maintenance of books of account.
- Security activities: - which are related to providing security to the property of the people in the organization. It is also called security sources.

FAYOL'S 14 PRINCIPLES:

1. **Division of work:** Dividing the work among different personal. So as to achieve specialization. This concept promotes efficiency and specialization at various levels. This is essential to achieve optimum

results in production, marketing, finance, HR, R & D activities. The success of an organization is also based on this principle.

2. **Authority and responsibility:** It means giving orders for superiors to subordinates generally. The authority wasted in the hands of superiors or top management in the organization. Top management means chairman, board of directors, MD & CEO. They have the decision making powers. Responsibility means obligation to accomplish by assigned as in most efficient and effective manner. Lack of responsibility leads to so many problems in the organization.
3. **Discipline:** It means obedience towards rules and retardations. It is nothing but showing respect to each other. It promotes dignity and honesty among the employee's and employers. It stabilizes superior subordinate relationship, no organization can successfully run without following this principles.
4. **Unity of command:** It means an employee must receive orders from our superior only for any action or activity. It avoid the confusion and conflict. Unity of command is essential for the success of an organization.
5. **Centralization:** It refers to concentration of authority at one place in the organization. In other words centralization means concentration of authority in the hands of a few top management personnel. These persons must take decisions. Decentralization means delegation of authority from top management to middle and lower levels. According to fayol there should be balance between centralization and decentralization. However he gave much importance to centralization.
6. **Unity of direction:** It refers to, there should be one head and one plan. It minimizes the risk and uncertainty at various levels. Unity of direction is essential for the successful running of an organization.
7. **Subordination of individual interest to general interest:** This principle is based on the assumption that organization is superior individuals. If there is any conflict between individual interest and general interest, the latter must prevail. It means the organization must be superior to individuals because organization is the basis for management.
8. **Scalar chain:** It refers to the process of flow of information from top to bottom and from bottom to top level management. Effective communication is essential for the successful running of an organization. There should not be any interruption in the flow of communication.
9. **Remuneration of personnel:** It refers to the process of payment of wages and salaries to workers and employee's. There should be fair and equitable wage and salary system in every industrial organization. Every organization must pay fair wages and salaries to workers and employees. Good remuneration system encourages workers and employee's to put more effort on production. Good remuneration system is essential for the success of an organization.
10. **Order:** It refers to placing right things at the right place. In other words is the process of maintaining men, money, and machinery in a systematic way or proper way. It role is also very prominent in the organization. Efficient order mechanism is essential for the success of an organization.

11. **Initiative:** It refers to taking actions and decisions independently. Every worker and employee must work with initiative.
12. **Stability of tenure:** It refers to stability in employment. Every organization must protect the existing employment and workers. They should provide job security to the employee's and workers. If they have job security they may pay more effort on production and ultimately the organization name and fame increases.
13. **Equity:** It refers to equal treatment without any discrimination. There is should not be any discrimination against cast, gender, religion, area... Etc. the organization must give equal importance to all cadres. They have to pay equal pay for equal work. There should not be any exploitation of labor force.
14. **Esprit de corps:** It refers to team spirit and team work. It is based on the principle of union is strength. It is nothing but devotion and loyalty towards the organizational goals.

HENRY FAYOL'S 14 PRINCIPLES THEN AND NOW:

Now let us see what Fayol's principles means in the contemporary business situations especially service based and high tech economies like USA. Carl A. Rodrigues of Mont Clair State University, Upper Montclair, New Jersey, USA has come out with the following conclusions in his paper "Fayol's 14 Principles of Management. Then and Now. A Framework for Managing Today's Organisations Effectively" published in Journal "Management Decision" 39/10(2001) PP 880-889.

Principles	Name of Principle	THEN	NOW
1	Division of Work	Specialisation in workers Job design Generalisation in workers' Job design	Generalisation in workers' Job design
2	Authority & Responsibility	Managers are empowered	Employees are empowered
3	Discipline	Formalised Controls	Informal, Peer pressure controls
4	Unity of Command	Subordinates report to only one boss	Subordinates report to multiple bosses
5	Unity of Direction	Functions have only one plan and one boss	Functions have multiple plans and multiple bosses
6	Subordination of individual interest to common good	Employees are committed to the organisation	Organisation is committed to the employees and vice versa
7	Remuneration of personnel	Reasonable Pay reward system	Performance based reward system
8	Centralisation	Trickle down decision making	Task relevant ad hoc decision making
9	Scalar Chain	Hierarchical, formalised communication channel	Less formalised, flatter communication structure

10	Order	Internal information system for control purposes	Internal information system for coordination purposes
11	Equity	Commitment obtained through kindness	Commitment obtained through a sense of ownership
12	Stability of tenure of personnel	Train employees and encourage them to remain	On-going employee training and development
13	Initiative	Managers conceive and implement new ideas	Workers conceive and implement new ideas
14	Espirit de corps	Maintaining high morale among employees is imperative	Maintaining high morale among employees is desirable.

COMPARISON: TAYLOR'S AND FAYOL'S PRINCIPLES OF MANAGEMENT:

Taylor's principles of scientific management and Fayol's principles of management are mutually complementary. Both of them evolved their principles through practical experience and brought them forward to the world through their books.

Both of them realized the importance of management in industrial progress. As a result, they endeavoured to develop a rational and systematic basis of management. However, the two pioneers differ from each other in the following aspects.

1. Taylor's principles and techniques are relevant mainly with respect to production activities. As he focused his attention on factory management, as a result, his principles are directly applicable at the shop floor. Whereas Fayol's principles have wider relevance in functional areas and his principles can be applied to all kinds of activities.
2. Taylor called his philosophy 'scientific management' whereas Fayol described his approach as 'General administration'.
3. Taylor's principles and techniques aimed at improving productivity of labour and following on workers' efficiency. Whereas Fayol focused on achieving managerial efficiency.
4. Taylor looked at the management from supervisory viewpoint and suggested principles with bottom upward approach. On the other hand, Fayol analysed management from the angle of top management based on top downward approach.

A comparison between the contributions of the two pioneers helps us to conclude that Fayol's theory is more widely applicable than that of Taylor's and has stood the test of time. However, Taylor's contribution to management is also very significant as it lends a scientific touch in solving managerial problems.

Sl.	Basis of difference	Henri Fayol	F. W. Taylor
1	Perspective	Top level of management	Shop floor level of a factory
2	Unity of Command	Staunch Proponent	Did not feel that it is important as under functional foremanship a worker received orders from eight specialists
3	Applicability	Applicable universally	Applicable to specialised situations
4	Basis of formation	Personal experience	Observations and experimentation
5	Focus	Improving overall administration	Increasing Productivity
6	Personality	Practitioner	Scientist
7	Expression	General Theory of Administration	Scientific Management

ROLE OF MATERIAL MANAGEMENT:

- To procure raw material at low cost.
- To maintain consistent quality.
- To ensure continuous supply of raw material.
- To minimize the carrying costs and ordering costs.
- To maintain good relationship with supplier.
- Efficient record-keeping and prompt reporting.
- To develop new sources and new materials.
- Training and development of personnel.

DISTINGUISH BETWEEN 'MANAGEMENT AND ORGANISATION':

MANAGEMENT	ORGANISATION
Management is defined as the process by which managers in an organization accomplish things through the efforts of other people in grouped activities.	Organization is an identifiable group of people Contributing their efforts towards the attainment of common goals.
Management is a profession which helps the individuals to perform every profession in a scientific manner.	Organization is a structure which defines her relationships between individuals and positions in an organization.
It helps in attainment of goals through limited resources.	Strong and result oriented internal organization helps in growing and diversifying the business.
Management helps in continuing the organization. It makes sure that business is continued.	Organization makes sure that manpower is recruited and effectively utilized at various organizational levels.
It makes sure that; organizational operations are carried out smoothly without any difficulty.	It makes' sure that all the resources are utilized in an optimum manner
Management is an art and science.	Organization is not an art or science. It is a social group designed for attaining certain goals.

IMPORTANT QUESTIONS IN UNIT -II FROM PREVIOUS QUESTION PAPERS

1. Define the terms industrial engineering and productivity. [8] April – 2015 Set 1
2. Explain the quantitative tools of IE and productivity measurement. [7] April – 2015 Set 1
3. Write the differences between production management and industrial engineering. [8] May/June – 2015 Set 1
4. Briefly discuss the importance of industrial engineering. [7] May/June – 2015 Set 1
5. Define Industrial engineering? Discuss the development and applications of industrial engineering. [7] May/June – 2015 Set 2
6. Discuss Quantitative tools of industrial engineering and productivity Measurement? [8] May/June – 2015 Set 2
7. Explain the concept of management and bring out its importance in present day Context. [7] May/June – 2015 Set 3
8. Discuss the principles of scientific management. [8] May/June – 2015 Set 3
9. What do you mean by management skills? How do skill requirements differ at various levels of management? [8] May/June – 2015 Set 4
10. Discuss Fayol's principles of management? [7] May/June – 2015 Set 4
11. Define Industrial management and give its advantages and applications. [8M] Dec – 2015 Set 1
12. Explain the functions of management. [7M] Dec – 2015 Set 1
13. Define Industrial Engineering. [3M] April – 2016 Set 1
14. Differentiate between production and productivity. [4M] April – 2016 Set 1
15. Explain the contributions of Taylor for scientific management and how it leads to the concept of scientific management. [8M] April – 2016 Set 1
16. State the functions of the management in an organisation. [4M] April – 2016 Set 1
17. Define scientific management. [3M] April – 2016 Set 2
18. State the role of an Industrial Engineer in shop floor. [4M] April – 2016 Set 2
19. Explain the tools that are used in Industrial engineering for solving managerial problems. [8M] April – 2016 Set 2
20. Describe the importance of management in an Organization. [4M] April – 2016 Set 2
21. What do you understand from the term production management? [3M] April – 2016 Set 3
22. Explain the scope and application of Industrial Engineering. [4M] April – 2016 Set 3
23. Explain Henri Fayol's principles of management thoughts. [6M] April – 2016 Set 3
24. State the relationship between Management, Administration and Organization. [6M] April – 2016 Set 3
25. How Industrial Engineering plays an important role in an industry? [3M] April – 2016 Set 4
26. Define Productivity. What are the different kinds of productivity measures? [6M] April – 2016 Set 4
27. Explain briefly about Douglas McGregor theory X and theory Y on motivation and management with the assumptions. [6M] April – 2016 Set 4
28. Differentiate between production management and Industrial engineering. [4M] April – 2016 Set 4

29. What is scientific management and explain its importance. [3M] Nov/Dec – 2016 Set 1
30. Discuss about the functions of management. [8M] Nov/Dec – 2016 Set 1
31. What is productivity? What are the methods that are used to measure productivity? [8M] Nov/Dec – 2016 Set 1
32. What do you understand from scientific management? Explain. [8M] Nov/Dec – 2016 Set 1
33. Explain Taylor's principles of management. [8M] Nov/Dec – 2016 Set 1
34. Explain the importance of an industrial engineer. [3M] April – 2017 Set 1
35. Describe the nature and importance of management in modern business organization. [8M] April – 2017 Set 1
36. Explain the system approach and contingency approach to management. [8M] April – 2017 Set 1
37. Briefly explain the development of industrial engineering. [3M] April – 2017 Set 2
38. Name and describe the various levels of management with their functions. [8M] April – 2017 Set 2
39. Give a brief note on:
    I. Classical theory of management II. Scientific management. [8M] April – 2017 Set 2
40. Differentiate between production management and industrial engineering. [3M] April – 2017 Set 3
41. Describe the various stages of evolution of management. [8M] April – 2017 Set 3
42. State and describe the Fayol's principles of management. [8M] April – 2017 Set 3
43. What are the quantitative tools of Industrial engineering? [3M] April – 2017 Set 4
44. State and describe the characteristics of modern management. [8M] April – 2017 Set 4
45. Describe the principles of scientific management in brief. [8M] April – 2017 Set 4
46. Explain the concept of management. What is its importance? [8M] April – 2017 Set 1
47. Explain the development of industrial engineering. [7M] April – 2017 Set 1
48. What is the difference between productivity and production? [3M] Nov/Dec – 2017 Set 1
49. Explain theory x and theory y and show as a manager how you would apply them to motivate your staff. [8M] Nov/Dec – 2017 Set 1
50. What is productivity? Enumerate the reasons for low productivity? [8M] Nov/Dec – 2017 Set 1
51. Write the differences between production management and industrial engineering.[8M] Nov – 2017 Set 1
52. State and describe the Fayol's principles of management. [7M] Nov – 2017 Set 1
53. Define management state the important characteristics of management. [4M] April – 2018 Set 1
54. What are the qualities required for an industrial engineer? [6M] Nov – 2017 Set 1
55. Describe the principles of scientific management in brief. [10M] Nov – 2017 Set 1
56. List out any four functions of management? [4M] April – 2018 Set 2
57. Differentiate between production management and industrial engineering? [6M] April – 2018 Set 2
58. Define scientific management. What are the criticisms to scientific management? Write the basic approaches to scientific management. [10M] April – 2018 Set 2
59. Differentiate between production management and industrial engineering? [4M] April – 2018 Set 3
60. What is McGregor theory X and theory Y? Explain. [8M] April – 2018 Set 3

61. Briefly describe the principles of management given by Henry Fayol?	[8M] April – 2018 Set 3
62. Bring out the contrast between theory X and theory Y?	[4M] April – 2018 Set 4
63. What are the functions of management?	[4M] April – 2018 Set 4
64. List out the applications of industrial Engineering?	[8M] April – 2018 Set 4
65. Briefly describe productivity measurement system?	[4M] April – 2018 Set 4

UNIT – II

PLANT LAYOUT

INTRODUCTION AND MEANING OF PLANT LOCATION:

WHAT IS PLANT LOCATION?

Plant location refers to the **choice of region and the selection of a particular site** for setting up a business or factory.

But the choice is made only after **considering cost and benefits** of different alternative sites. It is a strategic decision that cannot be changed once taken. If at all changed only at considerable loss, the location should be selected as per its own requirements and circumstances. Each individual plant is a case in itself. Businessman should try to make an attempt for optimum or ideal location.

Plant location or the facilities location problem is an important strategic level decision-making for an organisation. One of the key features of a conversion process (manufacturing system) is the efficiency with which the products (services) are transferred to the customers. This fact will include the determination of where to place the plant or facility.

The selection of location is a key-decision as large investment is made in building plant and machinery. It is not advisable or not possible to change the location very often. So an improper location of plant may lead to waste of all the investments made in building and machinery, equipment.

Before a location for a plant is selected, long range forecasts should be made anticipating future needs of the company. The plant location should be based on the company's expansion plan and policy, diversification plan for the products, changing market conditions, the changing sources of raw materials and many other factors that influence the choice of the location decision.

The purpose of the location study is to find an optimum location one that will result in the greatest advantage to the organization.

WHAT IS AN IDEAL LOCATION?

An ideal location is one where the cost of the product is kept to minimum, with a large market share, the least risk and the maximum social gain. It is the place of maximum net advantage or which gives lowest unit cost of production and distribution. For achieving this objective, small-scale entrepreneur can make use of location analysis for this purpose

Locational analysis is a dynamic process where entrepreneur analyses and compares the appropriateness or otherwise of alternative sites with the aim of selecting the best site for a given enterprise. It consists the following:

LOCATIONAL ANALYSIS

1) **Demographic Analysis:**- It involves study of population in the area in terms of total population (in no.), age composition, per capita income, educational level, occupational structure etc.

2) **Trade Area Analysis:**- It is an analysis of the geographic area that provides continued clientele to the firm. He would also see the feasibility of accessing the trade area from alternative sites.
3) **Competitive Analysis:**- It helps to judge the nature, location, size and quality of competition in a given trade area.
4) **Traffic analysis:**- To have a rough idea about the number of potential customers passing by the proposed site during the working hours of the shop, the traffic analysis aims at judging the alternative sites in terms of pedestrian and vehicular traffic passing a site.
5) **Site economics:**- Alternative sites are evaluated in terms of establishment costs and operational costs under this. Costs of establishment is basically cost incurred for permanent physical facilities but operational costs are incurred for running business on day to day basis, they are also called as running costs.

SELECTION CRITERIA

The important considerations for selecting a suitable location are given as follows:

- Natural or climatic conditions.
- Availability and nearness to the sources of raw material.
- Transport costs-in obtaining raw material and also distribution or marketing finished products to the ultimate users.
- Access to market: small businesses in retail or wholesale or services should be located within the vicinity of densely populated areas.
- Availability of Infrastructural facilities such as developed industrial sheds or sites, link roads, nearness to railway stations, airports or sea ports, availability of electricity, water, public utilities, civil amenities and means of communication are important, especially for small scale businesses.
- Availability of skilled and non-skilled labour and technically qualified and trained managers.
- Banking and financial institutions are located nearby.
- Locations with links: to develop industrial areas or business centers result in savings and cost reductions in transport overheads, miscellaneous expenses. Strategic considerations of safety and security should be given due importance.
- Government influences: Both positive and negative incentives to motivate an entrepreneur to choose a particular location are made available. Positive includes cheap overhead facilities like electricity, banking transport, tax relief, subsidies and liberalization. Negative incentives are in form of restrictions for setting up industries in urban areas for reasons of pollution control and
- Decentralization of industries.
- Residence of small business entrepreneurs want to set up nearby their homelands

WHAT ARE FACTORS THAT GOVERN PLANT LOCATION?

A plant is a place where men, money, machinery and equipment etc.., are brought together for manufacturing products. Plant location plays a vital role in the organization.

Governing factors:

1. Nearness to raw material.
2. Transport facilities.
3. Nearness to markets.
4. Availability of Labor.
5. Availability of fuel and power.
6. Availability of water.
7. Climatic conditions.
8. Financial and other aids.
9. Land
10. Community attitude.
11. Presence of related industries.
12. Existence of hospitals marketing centres, schools, banks, post offices, clubs etc..,
13. Local byelaws, taxes, building ordinances, etc.
14. Housing facilities.
15. Facilities for expansion.
16. Security.

1. **Nearness to raw material:**

This is one of the factor that influence plant location. The plant must be located very nearer to raw material. The raw material can be easily available to the plant. It will reduce the cost of transportation of raw materials from the vendors end to the plant. When the supplier of raw material is near the facility, then the immediate supply of the raw materials will be available.

2. Transport facilities:

This is also one of the factor that influence plant location. Transportation plays a vital role in transporting finished goods from manufacturing unit to market centres.

Money is spent in transporting raw material as well as finished goods, depending on the size of a raw materials and finished goods a suitable method of transportation such a road, rail, water or air is selected & accordingly plant location is decided. The cost of transportation must be fairly small compared to the total cost

3. **Nearness to markets:**

The plant must be located nearer to the markets. If it is located nearer to markets, the transportation charges can be minimized.

4. **Availability of Labor:**

The plant should be located where the labor force is available in plenty. Labor force plays a vital role in production.

5. **Availability of fuel and power:**

   The plant should be located where the fuel and power is available in sufficient. Power and fuel plays a vital role in production.

6. **Availability of water:**

   The plant should be located where the availability of water is in sufficient.

7. **Climatic conditions:**

   The plant should be located where the climate is congenial. Climate also play a vital role in production.

8. **Financial and aids:**

   The plant should be located where the financial institutions and support is in sufficient. Finance is the life blood of an organization. Adequate financial resources are necessary to produce goods.

9. **Land:**

   The plant should be located where the topography of land is good. Earth quakes floods etc.., may create so many problems.

10. **Community attitude:**

    The plant must be located in the place where the local community attitude is fine. The local community and their attitudes may influence the plant.

11. **Presence of related industries:**

    The plant must be located in the place where related industries are present. If there are related industries mutual help and cooperation may exit.

12. **Existence of hospitals marketing centres, schools, banks, post offices, clubs etc:**

    For the future benefits of the staffs and their family.

WHAT IS PLANT LAYOUT, EXPLAIN THE PRINCIPLES AND TYPES OF LAYOUTS?

The concept of plant layout has great significance in industrial organizations. Today every organization is giving much importance to plant layout. The success of an organization is also based on its plant layout. “The systematic arrangement of men, machinery and equipment in a given plant area. So, as to achieve maximum production with minimum cost is called plant layout”. It means keeping the machinery and equipment with in a given plant area. It can be defined as the process of determining a spatial location for the creation of physical production facilities suitable to manufacture a product.

Layout involves determining the space requirement for the facilities and arranging them in a manner to ensure steady flow of operations with minimum overall cost. In order words, a layout is a floor plan for arranging the desired facilities, machinery and equipment in an optimum locations so as to permit the

quickest flow of materials and manpower at the lowest cost and with the least amount of in process handling from receipt of raw material to shipment of finished products.

Since, a layout once made cannot be changed/modified easily and without incurring considerable cost on one hand and disrupting the operations on the other hand, layout decisions are strategic decisions. Hence, layout has to be considered at the time of planning a new venture. A good layout should result in comfort, convenience, better appearance, safety, efficiency and profits. A poorly planned layout causes congestion, disruption in flow of man and/or materials, accidents, delays, rejections leading to frustration and inefficiency. In a production unit layout includes factory design that is layout of workshop, raw material stock yards, finished goods stores, generator, compressor room etc.

For example In hospitals it involves fixing the location of wards, operation theatre, out-patient departments, canteen, doctors and nurses duty rooms etc. At another level layout planning involves layout of different machines, work stations etc., in the shop floor and patient's beds, drug store, doctors and nurses seats and other facilities in a hospital ward.

TYPES OF PLANT LAYOUT:

Two basic plans of the arrangement of manufacturing facilities are product layout and process layout. The only other alternative is a combination of product and process layouts, in the same plant.

VARIOUS TYPES OF PLANT LAYOUT:

The pattern of plant layout is based on number of products (P) and production quantity (Q). The various types of plant layouts are as follows:

(a) Product Layout (or Line Layout)

(b) Process Layout (or Functional Layout)

(c) Combination Layout

(d) Fixed Position Layout

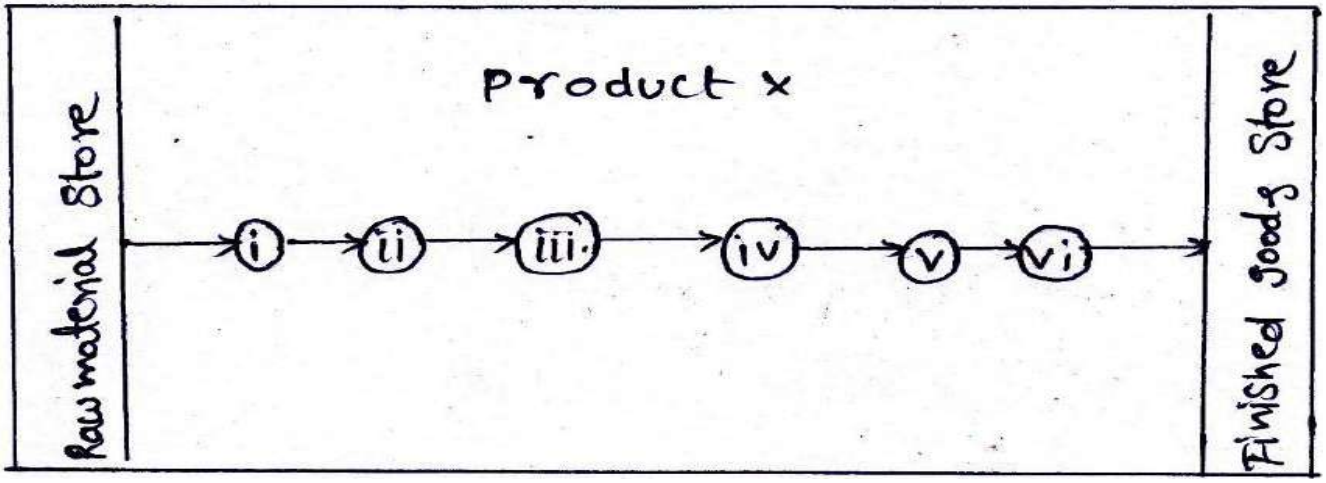
(a) PRODUCT LAYOUT (OR LINE LAYOUT):

In this type of layout, all the machines are arranged in the sequence, as required to produce a specific product. It is called line layout because machines are arrange in a straight line. The raw materials are fed at one end and taken out as finished product to the other end.

Special purpose machines are used which perform the required jobs (i.e. functions) quickly and reliably.

The following chart shows the production of commodity 'X' and its operations it requires six operations.

i. Drilling
ii. Boring
iii. Grinding
iv. Milling
v. Reaming
vi. Inspection.



ADVANTAGES:

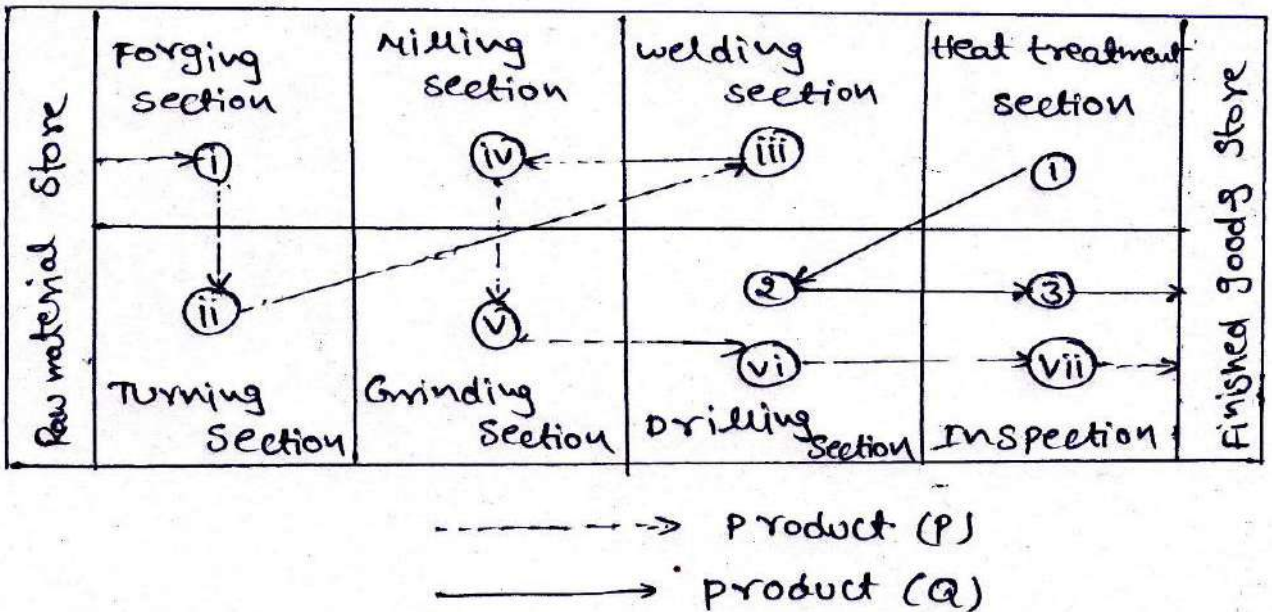
a. Faster and greater production.
b. Lower cost of material handling.
c. Easy monitoring.
d. Effective use of resources.
e. Team work benefits.
f. Maximum production with minimum cost.
g. Smooth and continuous work flow.
h. Product completes in lesser time.
i. Better coordination.
j. Simple production planning and control.
k. Less in process inventory.
l. Less space requirements for the same volume of production.

DISADVANTAGES:

a. Little flexibility.
b. Discontinuity in production lightly.
c. Monitoring each worker made difficult.
d. Use capital outlays.
e. Threat of duplication.

1. Process layout:

It is also called functional layout. If the layout is designed for different products and for different processes, it is said to be called process layout. In this case the machinery and equipment is arranged in a separate sections. For different products and for different operations. For example there are two products P and Q to be produced. For producing two products different types of machinery and processes to be followed. The process layout can be understood with the help of the following chart.



Advantages:

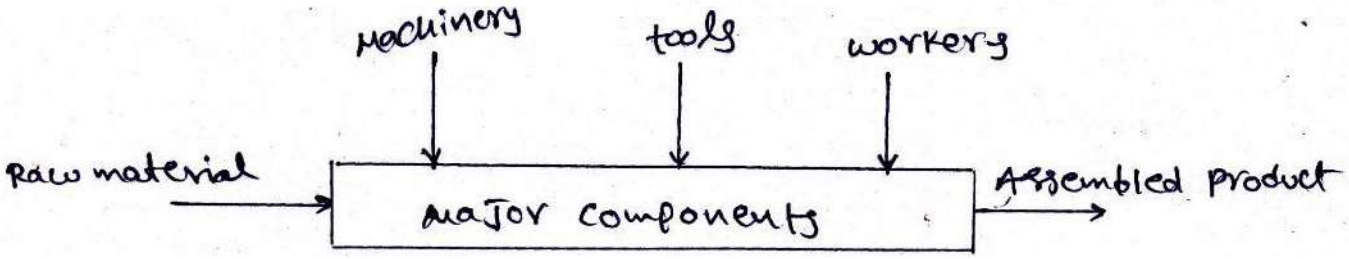
a. Maximum utilization of resources.
b. Flexibility.
c. Continuity.
d. Interesting to workers.
e. Easy to monitoring.
f. Convenient to workers.

Disadvantages:

a. Higher material handling cost.
b. Larger production cycle.
c. Monitoring may be complex.
d. Higher inspection cost.
e. Higher wagible.

2. Fixed layout:

If the layout is designed in a fixed position it is said to be called fixed layout. Here the material components remains stationary. Men, machinery tools … Etc. are brought to that location and assembled e product. Generally we can observe this type of layouts in large projects.



Advantages:

a. Does not involve large investment.
b. High degree of flexibility.
c. Workers find it very interesting.

Disadvantages:

a. Material handling cost will be very high.

b. At times the resources may be under-utilized.

TYPES OF PLANT LAYOUT:

Two basic plans of the arrangement of manufacturing facilities are product layout and process layout. The only other alternative is a combination of product and process layouts, in the same plant.

VARIOUS TYPES OF PLANT LAYOUT:

(b) Product Layout (or Line Layout)

(c) Process Layout (or Functional Layout)

(d) Combination Layout

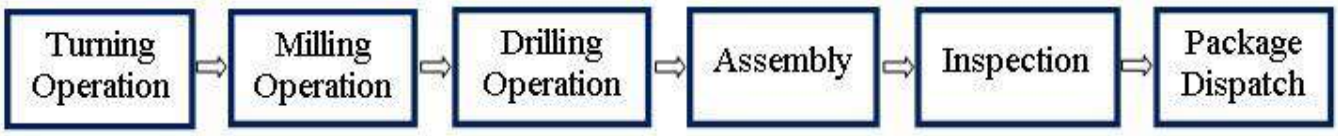
(e) Fixed Position Layout

A) PRODUCT LAYOUT (OR LINE LAYOUT):

In this type of layout, all the machines are arranged in the sequence, as required to produce a specific product. It is called line layout because machines are arrange in a straight line. The raw materials are fed at one end and taken out as finished product to the other end.

Special purpose machines are used which perform the required jobs (i.e. functions) quickly and reliably.

Product layout is depicted below:



ADVANTAGES:

1. Reduced material handling cost due to mechanized handling systems and straight flow
2. Perfect line balancing which eliminates bottlenecks and idle capacity.
3. Short manufacturing cycle due to uninterrupted flow of materials
4. Simplified production planning and control; and simple and effective inspection of work.
5. Small amount of work-in-progress inventory
6. Lesser wage cost, as unskilled workers can learn and manage production.

DISADVANTAGES:

1. Lack of flexibility of operations, as layout cannot be adapted to the manufacture of any other type of product.
2. Large capital investment, because of special purpose machines.

3. Dependence of whole activity on each part; any breakdown of one machine in the sequence may result in stoppage of production.
4. Same machines duplicated for manufacture of different products; leading to high overall operational costs.
5. Delicate special purpose machines require costly maintenance / repairs.

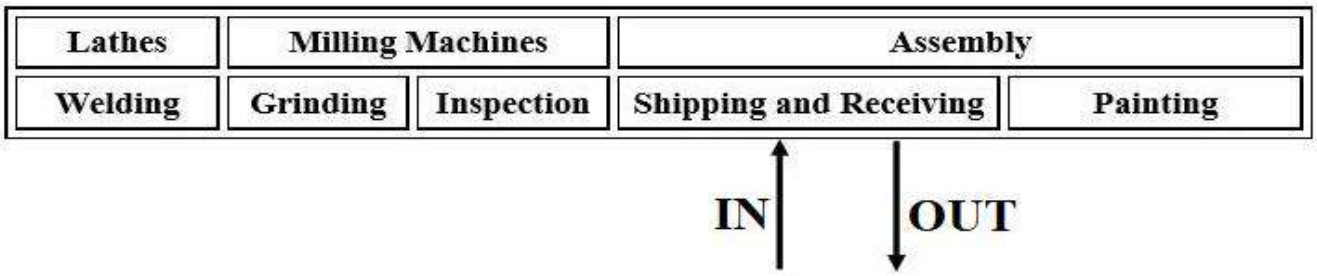
PRODUCT LAYOUT IS SUITABLE IN THE FOLLOWING CASES:

1. Where one or few standardized products are manufactured.
2. Where a large volume of production of each item has to travel the production process, over a considerable period of time.
3. Where time and motion studies can be done to determine the rate of work.
4. Where a possibility of a good balance of labour and equipment exists.
5. Where minimum of inspection is required, during sequence of operations.
6. Where materials and products permit bulk or continuous handling by mechanical parts.
7. Where minimum of set-ups are required.

B) PROCESS LAYOUT (OR FUNCTIONAL LAYOUT):

In this type of layout, all machines performing similar type of operations are grouped at one location i.e. all lathes, milling machines etc. are grouped in the shop and they will be clustered in like groups.

A typical process layout is depicted below:



ADVANTAGES:

1. Greater flexibility with regard to work distribution to machinery and personnel. Adapted to frequent changes in sequence of operations.
2. Lower investment due to general purpose machines; which usually are less costly than special purpose machines.
3. Higher utilisation of production facilities; which can be adapted to a variety of products.
4. Variety of jobs makes the work challenging and interesting.
5. Breakdown of one machine does not result in complete stoppage of work.

DISADVANTAGES:

1. Backtracking and long movements occur in handling of materials. As such, material handling costs are higher.
2. Mechanisation of material handling is not possible.
3. Production planning and control is difficult
4. More space requirement; as work-in-progress inventory is high-requiring greater storage space.
5. As the work has to pass through different departments; it is quite difficult to trace the responsibility for the finished product.

PROCESS LAYOUT IS SUITABLE IN THE FOLLOWING CASES, WHERE:

1. Non-standardised products are manufactured; as the emphasis is on special orders.
2. It is difficult to achieve good labour and equipment balance.
3. Production is not carried on a large scale.
4. It is difficult to undertake adequate time and motion studies.
5. It is frequently necessary to use the same machine or work station for two or more difficult operations.
6. During the sequence of operations, many inspections are required.
7. Process may have to be brought to work, instead of **"vice-versa"**; because materials or products are too large or heavy to permit bulk or continuous handling by mechanical means.

C) COMBINATION LAYOUT:

In practice, plants are rarely laid out either in product or process layout form. Generally a combination of the two basic layouts is employed; to derive the advantages of both systems of layout. For example, refrigerator manufacturing uses a combination layout.

Process layout is used to produce various operations like stamping, welding, heat treatment being carried out in different work centres as per requirement. The final assembly of the product is done in a product type layout.

D) FIXED POSITION LAYOUT:

It is also called stationary layout. In this type of layout men, materials and machines are brought to a product that remains in one place owing to its size. Ship-building, air-craft manufacturing, wagon building, heavy construction of dams, bridges, buildings etc. are typical examples of such layout.

PRINCIPLES OF PLANT LAYOUT:

The main principles of plant layout are:

1. Minimizing per unit cost.

2. Optimizing quality.
3. Effective use of manpower, machinery, equipment and space.
4. Employee's convenience, safety and comfort.
5. Realization of production targets with in a stipulated time period.
6. Achieving organizational goals in most efficient and effective manner.
7. To achieve maximum production with minimum cost.

WHAT IS MEANT BY PLANT MAINTENANCE?

A plant is a place where men, money, material, machinery, equipment …Etc are brought together for manufacturing products.

Plant maintenance:

Keeping the plant in good working condition to achieve maximum production with minimum cost by minimizing breakdowns is called plant maintenance. Today in modern industry equipment and machinery is a very important part of the total productive effort than was the case years ago. More over with the development of special purpose and sophisticated machines equipment and machinery cost a lot more money and therefore idle and down time becomes much more expensive.

Objectives of plant maintenance:

1. To minimize production breakages.
2. To keep the plant in good working condition.
3. Optimum utilization of machine capacity.
4. Optimum utilization of plant capacity.
5. To prevent accidents.
6. To provide security and safety to workers.

Importance of plant maintenance:

1. The importance of plant maintenance varies with that type of plant and its production.
2. Equipment breakdown leads to an inevitable loss of production. If a piece of equipment goes out of order inflow production factory, the whole line will soon come to a halt. Other production lines may also stop unless the initial fault is cleared.
3. An improperly maintained plant will sooner require expertize and frequent repairs, because with the passage of time. All machines facilities buildings wear out and need to be maintained to function properly.
4. Plant maintenance place a prominent role in production management. Because plant break down creates problems such as loss in production time, rescheduling of production spoilt materials failure to recover over headed.

To avoid all the above difficulties and problems proper maintenance of plant is essential.

DISCUSS ABOUT PREUENTIVE AND BREAKDOWN MAINTENANCE?

Preventive maintenance:

Preventive maintenance means maintaining the plant to prevent accidents. The main principle of preventive maintenance is that prevention is better than cure. It tries to minimize the problems of breakdown maintenance. It is a stich in time procedure. It locates weak spots in all equipment provides them regular inspection of the minor repairs there by reducing the danger of unanticipated break down.

Preventive maintenance involves the following aspects:

1. Periodic inspection of equipment and machinery.
2. To uncover conditions that lead to production break down and harmful depreciation.
3. Up keep of plant equipment to correct such conditions while they are still in a minor stage.

Objectives of preventive maintenance:

1. To minimize the possibility of unanticipated production interruption breakdown by locating and condition which may lead to it.
2. To maintain the value of equipment and machinery by periodic inspection repairs over hauls.
3. To make plant equipment and machinery always available and ready for use.
4. To maintain the optimum productive efficiency of the plant equipment and machinery.
5. To maintain the operational accuracy of the plant equipment.
6. To achieve maximum production at minimum repair cost.
7. To reduce the work content of maintenance jobs.
8. To ensure safety of life and limbs of the workmen.

Departments responsible for preventive maintenance:

1. Production departments.
2. Maintenance department.
3. A separate division of inspectors, crafts and supervisors. The above departments and persons are responsible for preventive maintenance.

Where to start preventive maintenance:

One should not apply preventive maintenance to the entire plant at once. This program should be built up in pieces when one piece is finished, start the next. The entire preventive maintenance program hangs on inspectors and their related duties of adjustments and repairs.

Machine Number	Machine Description	1	2	3	4	5	6	7	8	9
1201	lathe				C					O
162	Shaper		C					O		
980	Surface grinder			F						
650	Milling					F				

weekly PM schedule

C – Clean

O – Overhauling

F – Functional check

DISCUSS ABOUT BREAKDOWN MAINTENANCE?

It implies that repairs are made after the equipment is out of order and it cannot perform its normal function any longer.

Ex: an electric motor will not start a belt is broken.

Under such conditions production department calls on the maintenance department to rectify the defect. The maintenance department checks into the difficulty and makes the necessary repairs. After removing the fault maintenance engineers do not attend the equipment again until another failure brake down occurs. This type of maintenance may be quite justified in small factories.

Typical causes of equipment break down:

- Failure to replace worn out parts.
- Lack of lubrication.
- Neglected cooling.
- Indifference towards minor faults.
- External factors.
- Indifference towards equipment vibrations, unusual sounds, equipment getting too much heated up etc..,

Disadvantages:

- Excessive delays in production.
- Reduction of output.
- Faster plant deterioration.
- Increased chances of accidents and less safety to both workers and machines.

- More spoilt material.
- Direct loss of profit.

EXPLAIN THE QUANTITATIVE TECHNIQUES FOR OPTIMAL DESIGN OF LAYOUTS?

The concept of plant layout have great significance in industrial organizations. The systematic arrangement of men, material, machinery equipment in a given plant area. So as to achieve maximum production with minimum cost is known as plant layout.

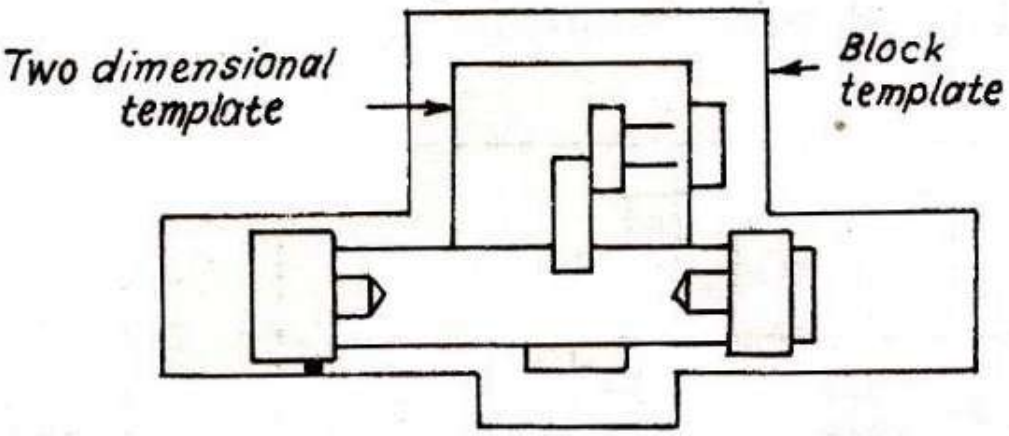
Quantitative techniques:

There are so many. They are process flow chart. There show how different component parts assembled in sequence of operations to form such assembles which in term lead to finished products. This chart how different parts can produce.

METHODS OF PIANT AND FACTORY LAYOUTS:

A layout furnishes details of the building to accommodate various facilities (like workers, material, machinery, etc.). In addition, it integrates various aspects of the design of a production system. The information required for plant laying out includes, dimensions of work places, sequence of operations, flow pattern of materials, storage space for raw material, in-process inventory and finished goods, offices, aisles, toilets, etc. During different development stages of a layout the following methods may be used.

1) **Process Flow Charts:** They show, how different component parts assemble, in sequence of operations to form sub-assemblies which in turn lead to assemblies (finished products).
2) **Material Movement Patterns:** The flow pattern of materials-in-process is traced and layout is built around it.
3) **Layout Analogues.** They cover two-dimensional cut outs or templates and three-dimensional models.
   a. **Templates or 2-D model:** They are used to develop plant layout. They are two-dimensional or block templates made up of cardboard, coloured paper or celluloid. They are made to scale (a typical scale being 1/50) and are placed on the scaled outline plan of the building. Templates or cut outs show the plan of the various facilities and the building. They show the actual floor space utilization. The templates can be placed and attached with a tape either on a board or on a cross-hatched surface or on a graph paper and thus being known as Graphic Technique.



Two-dimensional and block template.

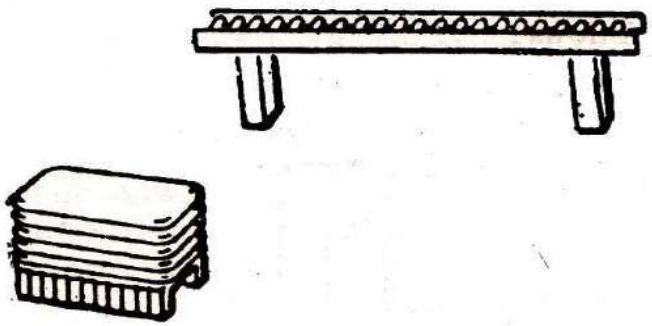
Advantages of Two-Dimensional Templates

1. They are the least costly.
2. They can be readily interpreted and followed by technical hands.
3. Duplicate copies can be made.

Disadvantages

1. Non-technical persons find it difficult to grasp the clear picture.
2. Overhead facilities cannot be visualized.

b. Three Dimensional Models: They are scale models of a facility and, more near to the real situation as, besides length and width they show the height of a facility also. Models are especially suitable for persons who are not familiar with plant layout practice. Models are made up of wood or die cast plastic. They show minor details and can be mounted on a thick plastic sheet acting as the floor plan. Models are used mainly to develop floor plans and elevations. Models can be made for production machines, workers, material handling equipment's or any other facility.



Advantages of Three-Dimensional Models:

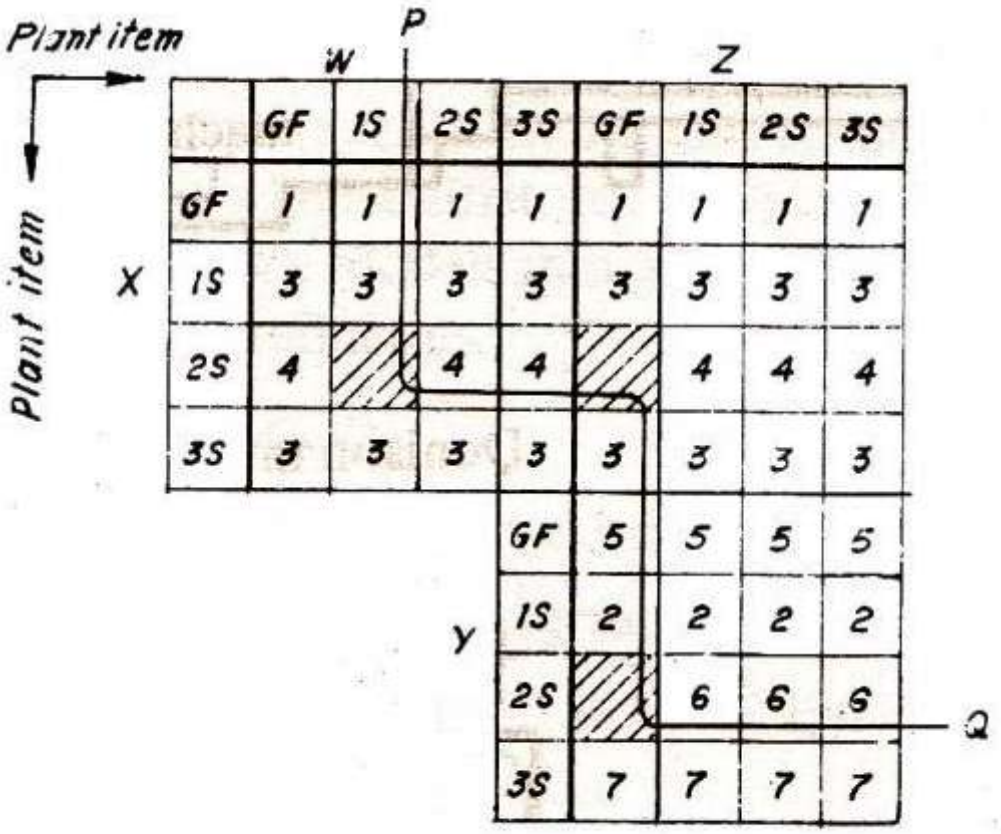
1. Layout is easier for the lay men to understand.
2. Layout can easily be explained to management.
3. Models can be shifted easily and quickly to study operational arrangements.
4. Overhead structures can be easily checked.

5. They convey more or less a real situation.

Disadvantages:

1. They require more storage area.
2. They are expensive.

4) **The Correlation Chart:** It involves drawing a grid with rows presenting alternative solutions (See Fig). Plant items can be ground floor, first floor or other floors of a multi-storey building. After the grid has been drawn the next step involves applying the constraints and objectives of layout. For example, the constraints to the layout may be that, (1) X cannot be done on ground floor (G.F.), (2) Y cannot be performed on first storey (1S). Similarly there can be objectives, (3) W should be done on second storey, and so on there are other objectives (4), (5), etc. Constraints and objectives are then applied to the squares. When a constraint stops an item going into a square, then in that square the number of that constraint is marked. After that the objectives or preferences are applied.



Correlation chart.

5) **Travel Chart:** A travel chart as the name suggests is a chart or record of the amount of travel by the material in-process while going from machine to machine or from one department to another. The amount of travel depends upon the frequency of movements between sections or departments. A travel chart helps improving the existing plant layout.

The

Following example will explain in a travel chart:

Existing plant layout showing the locations of various departments (A to F) is given in Fig. 4.11.

A	**B**	**C**
D	**E**	**F**

2nd Step: Movements A to B are 20;

(5) **Travel Chart.** A travel chart as the name suggests is a chart or record of the amount of travel by the material in-process while going from machine to machine or from one department to another. The amount of travel depends upon the frequency of movements between sections or departments. A travel chart helps improving the existing plant layout.

The following example will explain a travel chart :

Existing plant layout showing the locations of various departments (*A* to *F*) is given in Fig. 4.11.

A	*B*	*C*
D	*E*	*F*

Fig. 4.11. *Ist Step* : (Existing layout).

2nd step : Movements *A* to *B* are 20 ; *B* to *A*, *10* ; *B* to *C*, 15 ; *A* to *F*, 25 ; *C* to *D*, 30 ; *D* to *C*, 50 ; *D* to *F*, 40 ; *E* to *F*, 10 and *F* to *E*, 15.

3rd step : A square grid is drawn and the various movements are marked.

FROM / TO	A	B	C	D	E	F
A		10				
B	20					
C		15		50		
D			30			
E						15
F	25			40	10	

Fig. 4.12 *3rd step.*

FROM / TO	A	B	C	D	E	F
A						
B	30					
C		15				
D			80			
E						
F	25			40	25	

Fig. 4.13. *4th step.*

4th step : Fig 4.12 is simplified by combining movements like *A* to *B* (20) and *B to A* (10) which involve same distance and therefore total movements $B \rightleftarrows A = 20 + 10 = 30$.

The simplified travel chart (*See* Fig. 4.13) shows the movements as follows :

$A \rightleftarrows B = 30$

$B \rightleftarrows C = 15$

$C \rightleftarrows D = 80$

$A \rightleftarrows F = 25$

$D \rightleftarrows F = 40$

$E \rightleftarrows F = 25$

According to these figures maximum number of movements are between departments *C* and *D*, hence in the plant layout these two departments should be side by side. The next lesser number of movements are between *D* and *F*, hence *D* and *F* should also lie closer to each other and so on. As a result the existing plant layout can be modified as follows :

C	D	A
E	F	B

Fig 4.14. Modified Layout.

Departments *C* and *D* (80), *D* and *F* (40) , *A* and *B* (30), *A* and *F* (25), *E* and *F* (25) are closer to each other whereas *B* and *C* which have minimum number of movements (*i.e.*, 15) between them are away from each other.

A travel chart is advantageous because it brings out the relative importance of having different pairs of departments close to each other but it gives an optimum linear arrangement which may not be always required.

(6) **Load Path Matrix Method.** The method aims at reducing the transportation of in-process inventory from section to section. Like travel chart it also helps deciding the position of one department in relation to the other. The ultimate purpose is to modify the existing layout or the preliminary plant layout made by other techniques. The departments having mass flow of material or goods are placed close to each other. The following example will illustrate the method.

*Kgs of material moved per day.

FROM / TO	A	B	C	D	E	F
A		10				
B			15			
C	20 *			20		
D	40				25	5
E			28			
F					15	

Fig. 4.15 From–to matrix constructed from the actual given data. (*Step 1*).

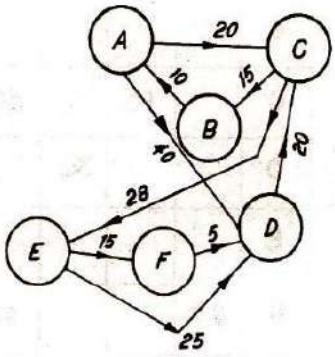


Fig. 4.16. (*Step 2*).

From the matrix (step 1) a diagram (*See* Fig. 4.16) is made showing the locations of different departments and the amount of material flowing among various departments (like *A, B, C,* etc.). Line joining *AC* shows that 20 kg. of material moves per day from department *A* to department *C* and so on. It can be seen that 40 kgs. of material while going from *A* to *D* passes *B*. If *D* department is brought in place of *B* then 40 kgs (*i.e.*, maximum) of material will move comparatively less distance. Similarly, material movements from *C* to *E* and *E* to *D* can be considered . The aim is to reconstruct this sequence diagram so that bigger loads travel small distances.

Step 3. Trial and error method can be used in order to modify the sequence diagram of step 2 and a comparatively better sequence diagram is drawn in Fig. 4.17. This has been obtained by placing those departments close to each other which involve movements of larger amounts of materials.

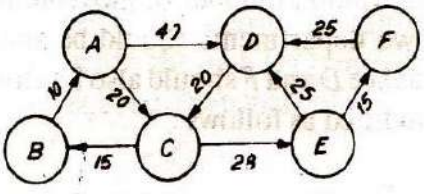


Fig. 4.17. Modified sequence diagram.

FACTORY BUILDING

Introduction

- After the plant location has been selected and plant layout decided upon, the next step is to construct plant or factory building to house and protect employees, equipments, tools, machinery, materials, etc.
- The factory building is the primary tool required to carry on production and into which all other production tools, processes and mechanisms must fit.
- *A good factory building*

(*i*) helps performing different operations most effectively ;

(*ii*) reduces material handling costs ;

(*iii*) minimizes production cycle time ;

(*iv*) reduces bottlenecks, stoppages and interruptions

(*v*) increases plant flexibility and efficiency ;

(*vi*) lowers down the maintenance costs ;

(*vii*) increases equipment and employees' safety ; and

(*viii*) has good appearance and provides healthy and pleasant working conditions.

UNIT – III

OPERATIONS MANAGEMENT

UNIT – III SYLLABUS:

OPERATIONS MANAGEMENT: Importance, types of production, applications, Work study, method study and time study, work sampling, PMTS, micro–motion study, rating techniques, MTM, work factor ~~system, principles~~ of Ergonomics, flow process charts, string diagrams and Therbligs.

INTRODUCTION

"Production and Operations management is defined as the design, operation and improvement of the transformation process, which converts the various inputs into desired outputs of products and services."

The term **"Production and Operations Management"** is being increasingly replaced by the simply operations management, as the production function relating to the manufacturing organizations has become a part of operations. Operations management also highlights the increasing importance of the service industry in the overall business environment.

"Production management deals with decision–making related to production processes so that the resulting goods or service is produced according to specification, in the amount and by the schedule demanded and at minimum cost.

DEFINITIONS:

Operations Management (OM) is a broad term which includes manufacturing as well as service organizations.

Operations Management (OM) is the management of transformations systems which convert inputs into good and/or services. The inputs to the system are materials, labor equipment's and capital

Operations Management (OM) is the science and art of ensuring that goods and services are created and delivered successfully to the customers.

PRINCIPLES OF OPERATIONS MANAGEMENT:

1) Understanding the needs of customers, measuring customer satisfaction and using that information to develop new and improved goods and services.
2) Using information about customers, goods, services, operations, supplier's employees, costs and finances to make better decisions.

3) Exploiting technology to design goods, services, manufacturing and service delivery processes that respond rapidly and flexibly to customer's requirements and to improve productivity.
4) Building quality into goods, services and processes and continually improving them to reduce error, defects and waste and to improve responsiveness and business performance.
5) Ensuring that material flows and associated operational activities are coordinated across hierarchical, organizational and functional boundaries.
6) Creating a high performance work place by developing the skills of employees and motivating them through education, training, rewards, recognition, teamwork, empowerment and other effective human resource practices.
7) Continually learning from co–workers, competitors, and customers and adapting the organization to global and environmental changes.

NATURE OF OPERATIONS MANAGEMENT:

- Operations management is dynamic in nature, it can be changed by the situation.
- Operation management is transforming the process from Raw material to finished goods.
- Operation management is the continuous process.
- Operation management is the main pillar of development and administration.
- Operation management helps to grow of the company.

IMPORTANCE OF OPERATIONS MANAGEMENT IN AN ORGANISATION:

There are various reasons which make operations management important. It encompasses both services and manufacturing, it's important in effectively and efficiently managing the productivity as every organization should have high productivity which can lead to economic growth and development, helps employees in receiving high wages as well as lead to increase in company's profit without causing inflation. Operations management is also important as it plays a strategic role in an organization's competitive success.

Below are few salient features indicating the importance of Operations Management for an organization:

- Operations management helps to **achieve the objectives** of the company.
- Operation management improves the **productivity of employees**.
- Operation management improves **goodwill and presence** of the organization.
- The manager will become more **able to utilize resources**.
- Operations management helps to **improve the motivation of employees**.

FUNCTIONS OF OPERATIONS MANAGEMENT IN AN ORGANIZATION:

1. Finance plays a main function in operations management. The operation manager should not waste finance in unproductive tasks.

2. The function of operation management is basically concerned with planning to directing of daily goals. So, the manager should make sure the effective work of the organization.
3. The strategy is also the main function of operation management. The manager should have pre-planned tasks.
4. It is the duty of operations manager to ensure the product's designed, that would be the market trends and demands.
5. Operations manager should ensure the quality of products. The manager should not compromise with the quality of Products.

SCOPE OF OPERATIONS MANAGEMENT:

The scope of operations management based on the interrelationship of three aspects, namely:

- **Structural aspects,** in the form of input that will be transformed according to criteria of the desired products, machinery, equipment, formulas and models.
- **Functional aspects,** namely the link between the component input, with the planning, implementation, control, and improvements to obtain optimum performance, so that operations can be run continuously.
- **Environmental aspects,** is the tendency that occurs outside the system, such as community, government, technology, economics, political, social, cultural, demonstrated ability to adapt.

Each manager will carry out basic functions of management processes. Management process consists of planning, organizing, Setting up employees, directing, and controlling.

Following are the activities, which are listed under Production and Operations Management functions

1. Location of facilities.
2. Plant layouts and Material Handling.
3. Product Design.
4. Process Design.
5. Production Planning and Control.
6. Quality Control.
7. Materials Management.
8. Maintenance Management.

1. LOCATION OF FACILITIES:

Location of facilities for operations is a long–term capacity decision, which involves a long–term commitment about the geographically static factors that affect a business organization. It is an important strategic level decision–making for an organization. It deals with the questions such as 'where our main operations should be based?'

The selection of location is a key–decision as large investment is made in building plant and machinery. An improper location of plant may lead to waste of all the investments made in plant and machinery equipment's. Hence, location of plant should be based on the company's expansion plan and policy, diversification plan for the products, changing sources of raw materials and many other factors. The purpose of the location study is to find the optimal location that will results in the greatest advantage to the organization.

2. PLANT LAYOUT AND MATERIAL HANDLING:

Plant layout refers to the physical arrangement of facilities. It is the configuration of departments, work centers and equipment in the conversion process. The overall objective of the plant layout is to design a physical arrangement that meets the required output quality and quantity most economically.

According to James More 'Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipment's and all other supporting services along with the design of best structure to contain all these facilities'.

'Material Handling' refers to the 'moving of materials from the store room to the machine and from one machine to the next during the process of manufacture'. It is also defined as the 'art and science of moving, packing and storing of products in any form'. It is a specialized activity for a modern manufacturing concern, with 50 to 75% of the cost of production. This cost can be reduced by proper section, operation and maintenance of material handling devices. Material handling devices increases the output, improves quality, speeds up the deliveries and decreases the cost of production. Hence, material handling is a prime consideration in the designing new plant and several existing plants.

3. PRODUCT DESIGN:

Product design deals with conversion of ideas into reality. Every business organization have to design, develop and introduce new products as a survival and growth strategy. Developing the new products and launching them in the market is the biggest challenge faced by the organizations.

The entire process of need identification to physical manufactures of product involves three functions; Design and Marketing, Product, Development, and manufacturing. Product Development translates the needs of customers given by marketing into technical specifications and designing the various features into the product to these specifications. Manufacturing has the responsibility of selecting the processes by which the product can be manufactured. Product design and development provides link between marketing, customer needs and expectations and the activities required to manufacture the product.

4. PROCESS DESIGN:

Process design is a macroscopic decision–making of an overall process route for converting the raw material into finished goods. These decisions encompass the selection of a process, choice of technology, process flow analysis and layout of the facilities. Hence, the important decisions in process design are to analyze the workflow for converting raw material into finished product and to select the workstation for each included in the workflow.

5. PRODUCTION PLANNING AND CONTROL (PP&C):

Production planning and control can be defined as the process of planning the production in advance, Setting the exact route of each item, fixing the starting and finishing dates for each item, to give production orders to shops and to follow–up the progress of products according to orders. The principle of production planning and control lies in the statement 'First Plan Your Work and then Work on Your Plan'. Main functions of production planning and control include Planning, Routing, Scheduling, Dispatching and Follow–up.

- **Planning** is deciding in advance what to do, how to do it, when to do it and who is to do it.
- Planning bridges the gap from where we are, to where we want to go. It makes it possible for things to occur which would not otherwise happen.
- **Routing** may be defined as the selection of path, in which each part of the product will follow and which is being transformed from raw material to finished products. Routing determines the most advantageous path to be followed for department to department and machine to machine till raw material gets its final shape.
- **Scheduling** determines the program for the operations. Scheduling may be defined as 'the fixation of time and date for each operation' as well as it determines the sequence of operations to be followed.
- **Dispatching** is concerned with the starting the processes. It gives necessary authority so as to start a particular work, which has been already been planned under 'Routing' and 'Scheduling'. Therefore, dispatching is 'Release of orders and instruction for the starting of production for any item in acceptance with the Route sheet and Schedule Charts'.
- The function of **Follow–up** is to report daily the progress of work in each shop in a prescribed proforma and to investigate the causes of deviations from the planned performance.

6. QUALITY CONTROL (QC):

Quality Control may be defined as 'a system that is used to maintain a desired level of quality in a product or service'. It is a systematic control of various factors that affect the quality of the product. Quality Control aims at prevention of defects at the source, relies on effective feedback system and corrective action procedure.

Quality Control can also be defined as 'that Industrial Management technique by means of which product of uniform acceptable quality is manufactured'. It is the entire collection of activities, which ensures that the operation will produce the optimum quality products at minimum cost.

The main objectives of Quality Control are:

1. To improve the company's income by making the production more acceptable to the customers i.e. by providing long life, greater usefulness, maintainability, etc.
2. To reduce companies cost through reduction of losses due to defects.
3. To achieve interchangeability of manufacture in large–scale production.
4. To produce optimal quality at reduced price.

5. To ensure satisfaction of customers with productions or services or high quality level, to build customer good will, confidence and reputation of manufacturer.
6. To make inspection prompt to ensure quality control.
7. To check the variation during manufacturing.

7. MATERIALS MANAGEMENT:

Materials Management is that aspect of management function, which is primarily concerned with the acquisition, control, and use of materials needed and flow of goods and services connected with the production process having some predetermined objectives in view.

The main objectives of Material Management are:

1. To minimize material cost.
2. To purchase, receive, transport and store materials efficiently and to reduce the related cost.
3. To cut down costs through simplification, standardization, value analysis, import substitution, etc.
4. To trace new sources of supply and to develop cordial relations with them in order to ensure continuous supply at reasonable rates.
5. To reduce investment tied in the inventories for use in other productive purposes and to develop high inventory turnover ratios.

8. MAINTENANCE MANAGEMENT:

In modern industry, equipment and machinery are a very important part of the total productive effort. Therefore their idleness or downtime becomes are very expensive. Hence, it is very important that the plant machinery should be properly maintained.

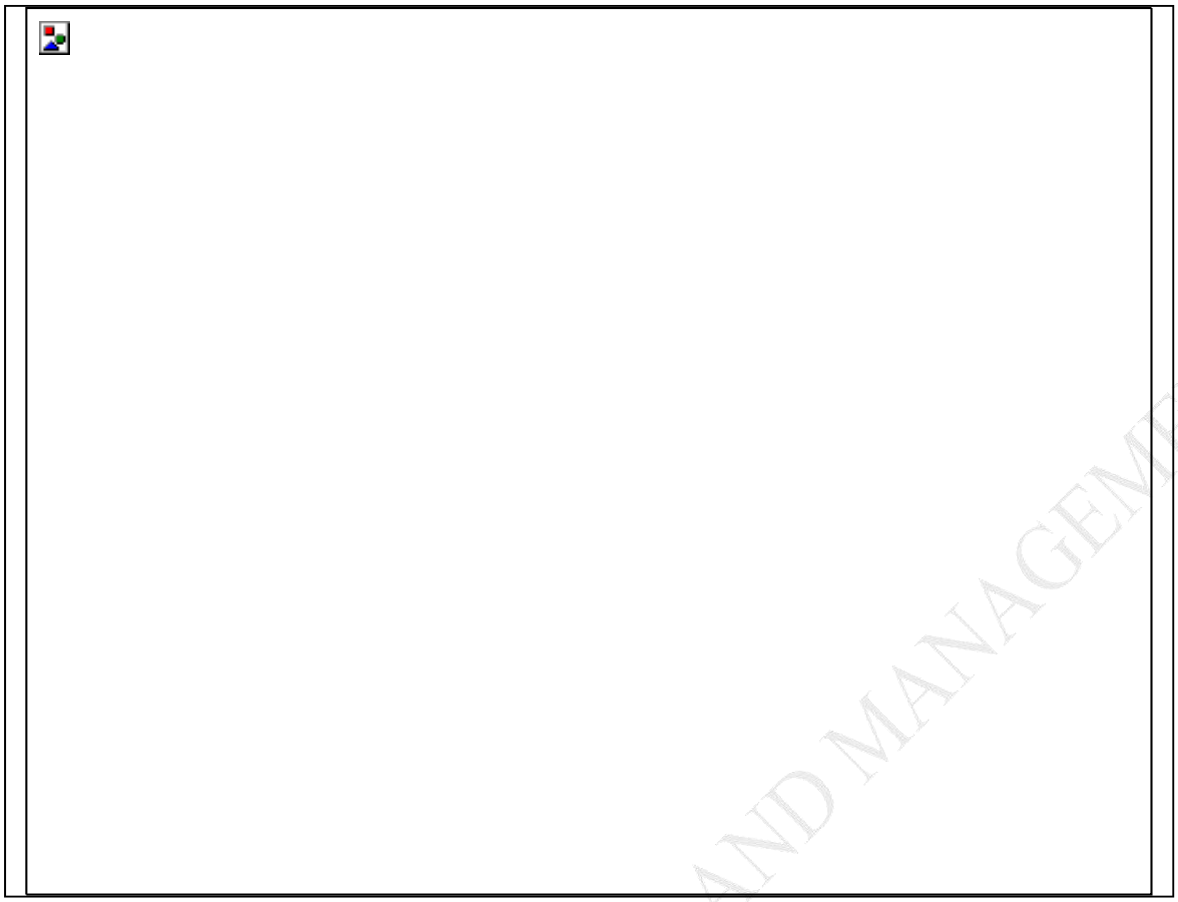
The main objectives of Maintenance Management are:

1. To achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.
2. To keep the machines and other facilities in such a condition that permits them to be used at their optimal capacity without interruption.
3. To ensure the availability of the machines, buildings and services required by other sections of the factory for the performance of their functions at optimal return on investment.

CLASSIFICATION/TYPES OF PRODUCTION SYSTEMS:

Production systems can be classified as

1. Job–shop Production,
2. Batch Production,
3. Mass Production and
4. Continuous production systems.



1. **JOB–SHOP PRODUCTION:**

Job–shop production are characterized by manufacturing one or few quantity of products designed and produced as per the specification of customers within prefixed time and cost. The distinguishing feature of this is low volume and high variety of products.

A job–shop comprises of general–purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in a certain sequence.

Job–shop Production is characterized by:

1. High variety of products and low volume.
2. Use of general purpose machines and facilities.
3. Highly skilled operators who can take up each job as a challenge because of uniqueness.
4. Large inventory of materials, tools, parts.
5. Detailed planning is essential for sequencing the requirements of each product, capacities for each work center and order priorities.

ADVANTAGES:

Following are the advantages of Job–shop Production:

1. Because of general purpose machines and facilities variety of products can be produced.
2. Operators will become more skilled and competent, as each job gives them learning opportunities.
3. Full potential of operators can be utilized.
4. Opportunity exists for Creative methods and innovative ideas.

LIMITATIONS:

Following are the limitations of Job–shop Production:

1. Higher cost due to frequent Set up changes.
2. Higher level of inventory at all levels and hence higher inventory cost.
3. Production planning is complicated.
4. Larger space requirements.

2. BATCH PRODUCTION:

American Production and Inventory Control Society (APICS) defines Batch Production as a form of manufacturing in which the job pass through the functional departments in lots or batches and each lot may have a different routing. It is characterized by the manufacture of limited number of products produced at regular intervals and stocked awaiting sales.

Batch Production is characterized by

1. Shorter production runs.
2. Plant and machinery are flexible.
3. Plant and machinery Set up is used for the production of item in a batch and change of Set up is required for processing the next batch.
4. Manufacturing lead–time and cost are lower as compared to job order production.

ADVANTAGES:

Following are the advantages of Batch Production:

1. Better utilization of plant and machinery.
2. Promotes functional specialization.
3. Cost per unit is lower as compared to job order production.
4. Lower investment in plant and machinery.
5. Flexibility to accommodate and process number of products.
6. Job satisfaction exists for operators.

LIMITATIONS:

Following are the limitations of Batch Production:

1. Material handling is complex because of irregular and longer flows.
2. Production planning and control is complex.
3. Work in process inventory is higher compared to continuous production.
4. Higher set up costs due to frequent changes in Set up.

3. MASS PRODUCTION:

Manufacture of discrete parts or assemblies using a continuous process are called Mass Production. This production system is justified by very large volume of production. The machines are arranged in a line or product layout. Product and process standardization exists and all outputs follow the same path.

Mass Production is characterized by

1. Standardization of product and process sequence.
2. Dedicated special purpose machines having higher production capacities and output rates.
3. Large volume of products.
4. Shorter cycle time of production.
5. Lower in process inventory.
6. Perfectly balanced production lines.
7. Flow of materials, components and parts is continuous and without any back tracking.
8. Production planning and control is easy.
9. Material handling can be completely automatic.

ADVANTAGES:

Following are the advantages of Mass Production:

1. Higher rate of production with reduced cycle time.
2. Higher capacity utilization due to line balancing.
3. Less skilled operators are required.
4. Low process inventory.
5. Manufacturing cost per unit is low.

LIMITATIONS:

Following are the limitations of Mass Production:

1. Breakdown of one machine will stop an entire production line.
2. Line layout needs major change with the changes in the product design.
3. High investment in production facilities.
4. The cycle time is determined by the slowest operation.

4. CONTINUOUS PRODUCTION:

Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc.

Continuous Production is characterized by

1. Dedicated plant and equipment with zero flexibility.
2. Material handling is fully automated.
3. Process follows a predetermined sequence of operations.
4. Component materials cannot be readily identified with final product.
5. Planning and scheduling is a routine action.

ADVANTAGES:

Following are the advantages of Continuous Production:

1. Standardization of product and process sequence.
2. Higher rate of production with reduced cycle time.

3. Higher capacity utilization due to line balancing.
4. Manpower is not required for material handling as it is completely automatic.
5. Person with limited skills can be used on the production line.
6. Unit cost is lower due to high volume of production.

LIMITATIONS:

Following are the limitations of Continuous Production:

1. Flexibility to accommodate and process number of products does not exist.
2. Very high investment for Setting flow lines.
3. Product differentiation is limited.

WORK STUDY INTRODUCTION:

Productivity has now become an everyday watch word. It is crucial to the welfare of industrial firm as well as for the economic progress of the country. High productivity refers to doing the work in a shortest possible time with least expenditure on inputs without sacrificing quality and with minimum wastage of resources.

Work-study forms the basis for work system design. The purpose of work design is to identify the most effective means of achieving necessary functions. This work-study aims at improving the existing and proposed ways of doing work and establishing standard times for work performance. Work-study is encompassed by two techniques, i.e., method study and work measurement.

"Method study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs."

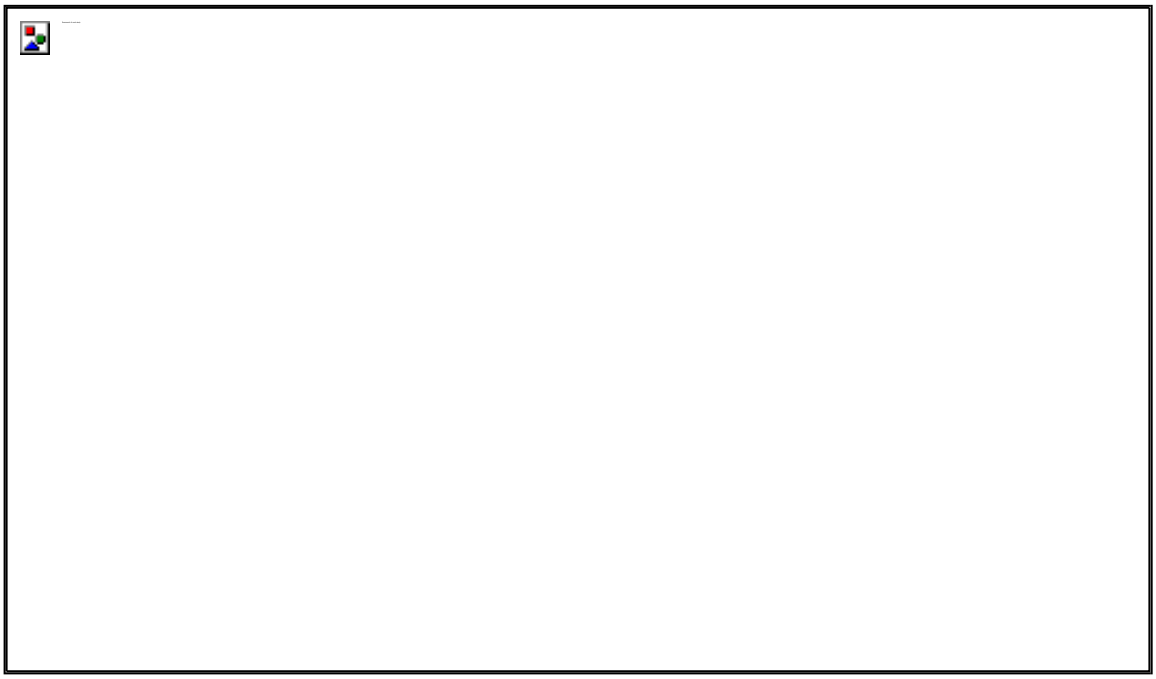
"Work measurement is the application or techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level or performance."

There is a close link between method study and work measurement. Method study is concerned with the reduction of the work content and establishing the one best way of doing the job whereas work measurement is concerned with investigation and reduction of any ineffective time associated with the job and establishing time standards for an operation carried out as per the standard method.

WORK STUDY IN PRODUCTION AND OPERATION MANAGEMENT:

"Work study is a generic term for those techniques, method study and work measurement which are used in the examination of human work in all its contexts. And which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement."

FRAMEWORK OF WORK STUDY:



Work study investigates the work done in an organization and aims at finding the best and the most efficient way of utilizing the available resources **(man, material, money and machinery)** to achieve best possible quality work in minimum possible time.

Work Study is systematic study of methods of work in order to improve effective use of its resources and Set standards of performance. It can be applied where a Set of processes is involved.

Work Study introduces the most effective method of working. It is the most efficient tool in the hands of management to improve efficiency at all levels of the organization. Work study helps to reduce waste through standardization of element of the job.

Work study is conducted in order to identify the current situation in the organization and to find the opportunities of improvement. This will help organizations become more systematic and profitable.

Work study deals with the techniques of method study and work measurement, which are employed to ensure the best possible use of human, machine and material resources in carrying out a specified activity.

OBJECTIVES OF WORK STUDY:

(i) Work study brings higher productivity;
(ii) Work study improves existing method of work for which cost becomes lower;
(iii) It eliminates wasteful elements;
(iv) It Sets standard of performance;
(v) It helps to use plant and human more effectively;
(vi) It improves by saving in time and loss of material also.

STEPS INVOLVED IN WORK STUDY:

The steps of work study are:

(i) It selects the jobs which are to be studied;
(ii) It examines critically the recorded facts which are already done;
(iii) It records from direct observations all the matters which are happened;
(iv) It defines new method;
(v) It also installs the new method;
(vi) It also maintains the new standard;
(vii) It develops most economic and appropriate methods.

It measures the work content in the method that is selected and compute a standard time.

APPLICATIONS OF WORK STUDY:

Work study finds applications in:

1. Industries (Production operations, research and development),
2. Marketing, sales and distribution,
3. Offices, stores and warehouses,
4. Material handling,
5. Design,
6. Building and other constructions,
7. Transport,
8. Hospital,
9. Army, and
10. Agriculture, etc.

BENEFITS OR ADVANTAGES OF WORK STUDY:

- It saves us a lot of time.
- Work study lays the foundation stone for all the work that will occur in the future.
- Work study provides you with tools and techniques that will help you to improve the way the production process is done.
- The work study helps you in Setting the standard or quality that is expected in the production process.
- The work study also helps you make decisions about the people involved, the process involved, machines and nature of jobs.
- With the help of work study the effect of production with respect to the employees, environmental factors, social factors can easily be understood.
- Also by doing work study you can come up with different ways to face any issues.

METHOD STUDY:

Method study of Motion study may be defined as the systematic investigation of existing method of doing job in order to develop and install an easy, rapid, efficient effective and less fatigue procedure for doing the same job at lower costs.

This is achieved by eliminating unnecessary motions involve in a certain procedure or by changing the sequence of operation of the process itself.

It is concerned with finding the facts about a situation and critical examination of these facts and developing a new and better methods of doing the work.

It is the systematic recording, analysis and critical examination of existing and proposed ways of doing work.

Method–study results in a more effective use of material, plant, equipment and manpower.

PROCEDURE FOR METHOD STUDY:

The process is often seen as a linear, described by its main steps of:

1) Select (the work to be studied);
2) Define (defines the aims, scale, scope and constraints of the investigation)
3) Record (all relevant information about that work);
4) Examine (the recorded information);
5) Develop (an improved way of doing things);
6) Install (the new method as standard practice);
7) Maintain (the new standard proactive).

1) SELECT:

Work selected for method study may be an identified problem area or an identified opportunity. It may be identified through a systematic review of available data, normal monitoring or control processes, high levels of dissatisfaction and complaint or as part of a change in management policy, practice, technology or location, and usually because it meets certain conditions of urgency and/or priority.

2) DEFINE:

Before any method study investigation is begun, it is necessary to establish, clear terms of reference which define the aims, scale, scope and constraints of the investigation. This should also include an identification of who "owns" the problem or situation and ways in which such ownership is shared. This may lead to a debate on the aims of the project, on reporting mechanisms and frequencies, and on the measures of success. This process is sometimes introduced as a separate and distinct phase of method study, as the "Define" stage. It leads to a plan for the investigation which identifies appropriate techniques, personnel, and timescale.

3) RECORD:

The Record stage of method study involves gathering sufficient data (in terms of both quality and quantity) to act as the basis of evaluation and examination. A wide range of techniques are available

for recording; the choice depends on the nature of the investigation; the work being studied; and on the level of detail required. Many of the techniques are simple charts and diagrams, but these may be supplemented by photographic and video recording, and by computer based techniques.

Especially with "hard" (clearly defined) problems, method study often involves the construction and analysis of models, from simple charts and diagrams used to record and represent the situation to full, computerised simulations. Manipulation of an experimentation on the models leads to ideas for development.

4) EXAMINE:

The recorded data are subjected to examination and analysis; formalised versions of this process are critical examination and systems analysis. The aim is to identify, often through a structured, questioning process, those points of the overall system of work that require improvements or offer opportunity for beneficial change.

5) DEVELOP:

The Examine stage merges into the Develop stage of the investigation as more thorough analysis leads automatically to identify areas of change. The aim here is to identify possible actions for improvement and to subject these to evaluation in order to develop a preferred solution.

Sometimes it is necessary to identify short–term and long–term solutions so that improvements can be made (relatively) immediately, while longer–term changes are implemented and come to fruition.

6) INSTALL:

The success of any method study project is realised when actual change is made ‘on the ground’, change that meets the originally specified terms of reference for the project. Thus, the Install phase is very important. Making theoretical change is easy; making real change demands careful planning and handling of the people involved in the situation under review. They may need reassuring, retraining and supporting through the acquisition of new skills. Install, in some cases, will require a parallel running of old and new systems, in others, it may need the build–up of buffer stocks, and other planning to manage the change. What matters is that the introduction of new working methods is successful. There is often only one chance to make change!

7) MAINTAIN:

Sometime after the introduction of new working methods, it is necessary to check that the new method is working, that it is being properly followed, and that it has brought about the desired results, this is the Maintain phase. Method drift is common when people either revert to old ways of work in, or introduce new changes. Some of these may be helpful and should formally be

incorporated; others may be inefficient or unsafe. A methods audit can be used to formally compare practice with the defined method and identify such irregularities.

WORK MEASUREMENT OR TIME STUDY:

Work measurement is also called by the name 'time study'. Work measurement is absolutely essential for both the planning and control of operations. Without measurement data, we cannot determine the capacity of facilities or it is not possible to quote delivery dates or costs. We are not in a position to determine the rate of production and also labor utilization and efficiency. It may not be possible to introduce incentive schemes and standard costs for budget control.

Time And Motion Study: According to ILO, Time Study means "A technique for determining as accurately as possible from a limited number of observations the time necessary to carry out a given activity at a different standard of performance". In other words, "time study is the art of observing and recording time required to do each detailed element of an individual operation." Practically, it studies the time taken on each element of a job.

Motion study, on the other hand, is the study of the body motion used in performing an operation, with the thought of improving the operation by eliminating unnecessary motion and simplifying necessary motion and thus establishing the most favourable motion sequence for maximum efficiency.

So, in short, 'Time Study' means the determination of standard time that is taken by a worker of average ability under normal working conditions for performing a job. But 'Motion Study' determines the correct method of doing a job to avoid wasteful movements, for which the workers are unnecessarily tired.

STEPS INVOLVED IN TIME AND MOTION STUDY:

The steps of Time And Motion Study are:

1. Time and Motion studies eliminate wasteful movements;
2. They examine the proposed method critically and determine the most effective one;
3. They determine for each element having a stop-watch;
4. They record all the parts of a job which are done by the existing method;
5. They install the method as standard one;
6. They critically observe the workers who are engaged with the work;
7. They assess the proper speed of the operator who is working.

Time Study or Work measurement is the application of techniques designed to establish the time taken for a qualified worker to carry out a specified job (task) at a defined level (rate) of performance.

Or

Time study is a technique to estimate the time to be allowed to a qualified and well–trained worker working at a normal pace to complete a specified task.

This technique is based on measuring the work content of the task when performed by the prescribed method, with the allowance for fatigue and for personal and unavoidable delays.

MEANING OF WORK MEASUREMENT:

The meaning of work measurement is mainly based on three key steps.

Work measurement means to:

- Find out the different elements (parts) of the production process (job).
- Find out the time taken by each element.
- Fix the standard time for performing the production process.

For example, publishing a book is a production process. There are many elements, which are involved in the publication of a book. In other words, book publication involves production steps like typing a manuscript, editing the written matter; proof reading, followed by printing and binding.

Work measurement involves finding out the time taken for doing each element. The time taken for each element is totalled. This is the standard time for publishing the book. Here, provisions are also made for relaxation, breakdown of machines, etc.

OBJECTIVES AND APPLICATIONS OF WORK MEASUREMENTS:

OBJECTIVES OF WORK MEASUREMENT:

The use of work measurement as a basis for incentives is only a small part of its total application. The objectives of work measurement are to provide a sound basis for:

1. Comparing alternative methods.
2. Assessing the correct initial manning (manpower requirement planning).
3. Planning and control.
4. Realistic costing.
5. Financial incentive schemes.
6. Delivery date of goods.
7. Cost reduction and cost control.
8. Identifying substandard workers.
9. Training new employees.

TECHNIQUES OF WORK MEASUREMENT IN PRODUCTION MANAGEMENT:

For the purpose of work measurement, work can be regarded as:

1. ***Repetitive work*:** The type of work in which the main operation or group of operations repeat continuously during the time spent at the job. These apply to work cycles of extremely short duration.
2. ***Non-repetitive work:*** It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

Various techniques of work measurement are:

1. Time study (stop watch technique),
2. Synthesis,
3. Work sampling,
4. Predetermined motion and time study,
5. Analytical estimating.

Time study and work sampling involve direct observation and the remaining are data based and analytical in nature.

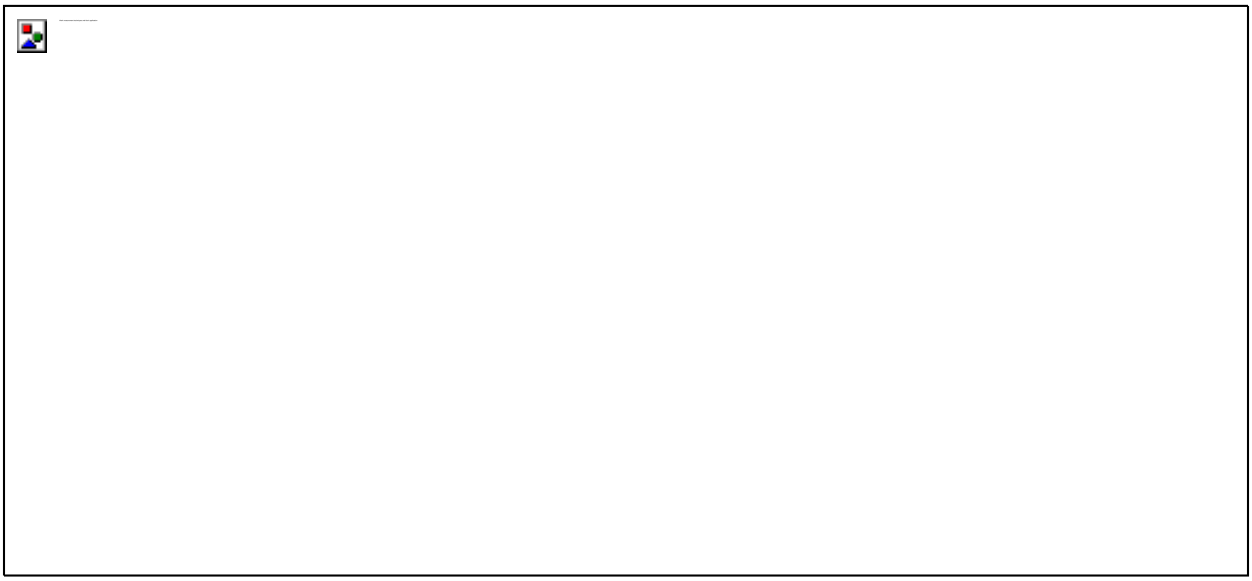
1. ***Time study*:** A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analysing the data so as to determine the time necessary for carrying out the job at the defined level of performance. In other words measuring the time through stop watch is called time study.
2. ***Synthetic data:*** A work measurement technique for building up the time for a job or pans of the job at a defined level of performance by totalling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.
3. ***Work sampling:*** A technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.
4. ***Predetermined motion time study (PMTS):*** A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and

conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as Methods Time Measurement (MTM).

5. ***Analytical estimating:*** A work measurement technique, being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data. The work measurement techniques and their applications are shown in the following table.

WORK MEASUREMENT TECHNIQUES IN OPERATIONS MANAGEMENT:

Work measurement techniques and their application



PURPOSE OF WORK MEASUREMENT

THE PURPOSE OF WORK MEASUREMENT DATA:

1. Manpower planning.
2. Production Planning and Scheduling.
3. Estimating Productions Costs.
4. Cost Reduction and Control.
5. Rational Basis for Incentives.
6. Performance Appraisal.
7. Training of Employees.
8. Comparing Alternative Methods.
9. Accepting New Orders.
10. Fixing the Selling Cost.

1) MANPOWER PLANNING:

Work measurement data is used for manpower planning. This is because it gives information about the total hours required to perform the job. This helps to estimate the number and type of employees who are required to do the job. It ensures that there will not be any excess staff.

Work measurement data also helps to estimate the number of machines and equipment that will be required in the future. This helps to find out the number of employees who will be required to handle these machines and equipment.

2) PRODUCTION PLANNING AND SCHEDULING:

Work measurement data is used for production planning and scheduling. This is because this data is used for making production standards. This data is also used for scheduling. Scheduling means to fix starting and finishing time for each job. This cannot be done without work measurement data.

3) ESTIMATING PRODUCTIONS COSTS:

Work measurement data helps to estimate the production cost. This is because it gives management accurate data about production time. This data helps to estimate the labor costs. Secondly, indirect costs such as fuel and power consumption, rent and salaries of staff, etc. also depends on the production time factor.

4) COST REDUCTION AND CONTROL:

Work measurement data is used to reduce and control costs. It helps to reduce the labor cost. This is because it provides a guideline to the employees to work efficiently and effectively. This helps to make optimum use of the available manpower. So the labor cost will reduce.

Work measurement data helps to reduce material costs. It also helps to increase machine productivity. All these steps help to reduce and control production costs.

5) RATIONAL BASIS FOR INCENTIVES:

Work measurement data is used for making incentive schemes for the employees. Incentive schemes motivate employees to work hard. The efficient employees are rewarded by giving them a higher wage rate.

Work measurement fixes the standard–time for doing the work. Those who complete their work within a standard time or faster than the standard–time are rewarded with higher wages. This encourages all employees to work fast and efficiently.

6) PERFORMANCE APPRAISAL:

Performance appraisals are done to find out whether the employees are efficient or not. It is done to find strengths & weaknesses of employees.

Work measurement helps to do performance appraisals. This is because it fixes the standard–output and standard–time for each employee. The employees who produce the standard–output within the standard–time are efficient and vice versa. Thus, it also helps to find out the strengths and weaknesses of the employees.

7) TRAINING OF EMPLOYEES:

Work measurement helps to train the employees, especially the new employees. It divides the full job into small elements (parts). It gives complete details about each element of the job. It gives details about; how to do each element, the time taken for each element, the machines and tools involved in each element, etc. These details are used for training the employees.

8) COMPARING ALTERNATIVE METHODS:

There are many methods for doing a job. Work measurement data helps to choose the best method for doing a job.

9) ACCEPTING NEW ORDERS:

Work measurement data tells us when each job will be completed. So, it helps the company to decide whether to accept new orders or not. In other words, it helps to find out whether the new–order will be completed within a specific time limit.

10) FIXING THE SELLING COST:

Work measurement data also helps to fix the selling cost of product. This is because it estimates the cost of production, especially the labor cost. Selling cost is decided after fixing the estimated production cost.

WORK SAMPLING:

Meaning of Work Sampling:

Work sampling, also called 'Activity Sampling' or 'Ratio Delay Study', is based on the statistical method first devised and was original developed by **Leonard Henry Caleb Tippett (1902–1985) in Britain in 1934.** He used this technique firstly, in the British textile industry. Later Morrow carried out several investigations.

In this technique, **the workers are observed many times at random**. It is done to find out for how much time the worker is actually on the job. It checks how long he is working and how much time he is not working (idle time).

Work sampling method does not involve stop watch measurement. The purpose of work sampling technique is to estimate what proportion of a worker's time is devoted to work–related activities.

The results obtained by the all-day stop-watch time study and such other statistical methods were in most cases found to be in close agreement with the work sampling method, which places it on a sound reliable basis.

Though stop-watch time study proved to be very useful for repetitive operations but it cannot measure accurately and economically long and irregular work cycles. While most of the indirect activities are of

irregular nature and, therefore, there must be some way to control the indirect labour activities. For such tasks work sampling has been well established and gained lot of popularity.

Workers have wrong concept that the results of a time study may go against them and reduce their wage rates. Therefore, they oppose the stop-watch method. For this technique, workers have no such feelings.

"Work Sampling is a technique of getting idea about utilization of machines or human beings through a large number of instantaneous observations taken at random time intervals".

OBJECTIVES OF WORK SAMPLING:

Work sampling is a fact finding tool and has the following two main objectives:

1. To measure activities and delays while a man is working and percentage of that he is not working. It means a fair day's work.
2. Under certain circumstances, to measure manual tasks that is to establish time standards for an operation.

Work sampling method involves following three main steps:

- Deciding what activities are defined as 'working'. Non–working are those activities which are not defined as working.
- Observe the worker at selected intervals and record (write down) whether he is working or not.
- Calculate the portion of time (P), a worker is working**.**

DETERMINATION OF TIME STANDARDS BY WORK SAMPLING:

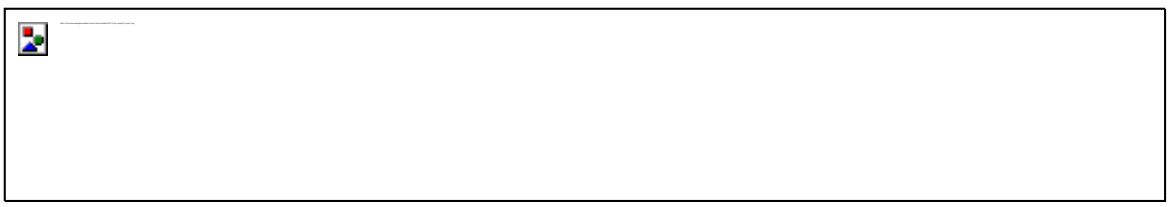
With work sampling, it is possible to determine the percentage of the day a worker is idle and the percentage of the day he is working. The average performance index or the speed at which he worked during the working portion of the day, can also be determined.

For example, suppose Mohan Singh worked as a Drillman, and a work sampling study showed that he was idle 15% of the day or 72 minutes and that he worked the remainder of the day of 480 minutes at an average performance index of 110%. He drilled 400 items of acceptable quality during the day.

The standard time for the operation he performed can be calculated as shown below:

It is assumed that 15% of the total time is taken as fatigue and other personnel allowances.

As Standard Time



$$= \frac{100}{100-15} \times \frac{(480 \times 0.85 \times 1.10)}{400} \; 1.32 \; Minutes$$

APPLICATIONS OF WORK SAMPLING:

1. Work sampling can be applied for the estimation of the percentage utilization of machine tools, cranes, fork trucks etc.
2. Work sampling can also be used to estimate the unavoidable delay times for deciding the delay allowances.
3. To estimate the percentage of the time consumed by various job activities, i.e. supervision, repair, inspection etc.
4. Work sampling is also used to find out time standards, specially where the job is not repetitive and where time study by stop-watch method is not possible, e.g. for maintenance work, office work, repair work, ship building etc. Time standards can be calculated by combining rating with work sampling as illustrated in the following example:

Example 2:

A work sampling study showed that 20% of a work week of 48 hours was consumed by avoidable, delays. If each time a work sampling observation was made the operator was rated and the average of such rating was 110%. If 100 units were produced by the operator in that period, calculate standard time.

Solution:

ADVANTAGES OF "WORK SAMPLING" OVER "TIME STUDY":

1. Operator is not subjected to long-period of observations.
2. Group operations can be easily studied by a single analyst.

3. It does not require continuous observation for a long period of time.
4. Many operations or activities which are impractical or costly to be measured by time study can be measured by this.
5. Observations may be taken over a period of days or weeks, thus decreasing the chance of day to day or week to week variations affecting the results.
6. The man hours spent by the analyst are much less.
7. A work sampling study can be stopped at any time without affecting the results.
8. In this, random observations are taken by avoiding prolonged observations.
9. This produces less fatigue and are less tedious to observer.
10. It generally requires less time in calculating the results.
11. No stop-watch or any other timing device is needed.
12. Clerical time is minimised.

DISADVANTAGES OF "WORK SAMPLING" OVER "TIME STUDY":

1. It is not economical to study a single operator or machine or for studying operators or machines located over wide areas.
2. It does not permit finer breakdown of activities and delays.
3. Study made of a group presents average while there is no information about the magnitude of individual differences.
4. Management and workers may not be able to understand work sampling as easily as they do time study.
5. Some-time no record is kept about the study on the operator, therefore, a new study must be made when a change occurs in any element.

ERRORS IN WORK SAMPLING STUDY:

While conducting the Work Sampling Study some errors are likely to be occurred. Therefore, care must be taken to avoid these errors.

Following are some of the errors which generally occur:

1. Sampling Errors,
2. Bias in work sampling, and
3. Non-representativeness.

1. **Sampling Errors:** In sampling study, whole population is represented by a sample. If the size of the sample is small, then there are chances of errors in inference drawn from this sample. Therefore,

while conducting the study care must be taken that sample size must represent the same characteristics as that of the whole population.

The sample size can be calculated using the formulae, after a confidence level and level of accuracy is decided. After completing the study, it must be checked, whether sufficient number of observations have been taken or not.

2. Bias in Work Sampling: As a consequence of bias in study, the proportion of an activity (working or idle) shall be different from the actual proportion of time devoted to that activity.

Following are the main sources of bias study:

I. **A Non-Random Schedule of Observation:** To avoid this error, randomised sampling procedure must be adopted. Before starting the study, actual schedule of observations must be designed.

Once the number of observations have been estimated (after deciding the confidence level and accuracy) using the formula and a representative period (number of days over which the study in spread-up) of study has been selected, the number of observations (N) are distributed over the total number of days selected.

Then this number is distributed randomly over the day. For this purpose any random number table may be used.

For example, following numbers are taken from the random number table:

Then using these numbers, we can fix the schedule as:

3rd hour 12th min. 58th sec.

2nd hour 54th min. 10th sec (leaving Number 9)

1st hour 35th min. 8th sec.

5th hour 14th min. 40th sec.

These times are then chronologically arranged to complete the observation schedule.

As a second way, these numbers can also be used to indicate as (leaving last number).

II. Rias on the Part of the Observer: Sometimes when the observer observes the worker he is in transitional states, i.e. he is changing from one state to another state, and then the observer can call it either way. In such cases, the observer's judgment is required.

To avoid any possibility of bias, following precautions must be taken to minimise the judgments:

(a) Categories must be defined very clearly.

(b) Clearly define the instant at which the observation is to be made. For this purpose, a turn of the corner is preferred so that the category at the time of first seeing can be noted.

(c) If any transitional stage cannot be defined clearly, even then judgment is avoided and tossing of coin must be done.

III. Change in the Behaviour of the Worker: Sometime when the observed person knows that he is being observed then he changes his behaviour.

To take care of this error, following precautions must be taken:

(a) Observations must be randomly spaced.

(b) Observations must be taken as soon as the operator is in sight of the observer.

(c) Randomise the order in which individual worker is observed, when more workers are to be observed.

3. Non-Representativeness in Work Sampling: Non-representativeness exists when the period studied do not give characteristics of the circumstances that prevail in the long run. For example, results taken on any one day cannot represent all the days. On Monday the worker is fresh while on Friday and Saturday he will be tired.

Similarly, the results taken in the day shift evening shift and in the night shift will be different. Some problems are for seasons, i.e. results taken in the summer cannot be applied in the winter or in the rainy seasons.

Therefore, designer of a work sampling study must give a careful attention to representativeness of the sample. Periods of abnormal activities and unusual conditions should be avoided.

ADVANTAGES/BENEFITS OF WORK SAMPLING:

1. Work sampling gives an unbiased result since workmen are not under close observation.
2. A work sampling study may be interrupted at any time without affecting the results.
3. Work sampling can be conducted by anyone with limited training. There is no need to have experts.
4. Team work can be studied by work sampling and not by the time–study.

5. Work sampling is economical and less time–consuming than time study. This is because more than one worker can be studied at the same time. Secondly, observer needs not to be present himself for a long time.

DISADVANTAGES/DEMERITS OF WORK SAMPLING:

1. Work sampling is not economical for short cycle jobs. It is also uneconomical to study a single worker or even small group of workers.
2. Unlike time study, it does not allow a small breakdown of activities and delays.
3. Working men may change their normal method of working when they see an observer. Therefore, the results from the work study may not be accurate.
4. In work sampling method, the observations are limited or insufficient. So, the results may not be accurate.
5. This method normally does not record the workers' speed of working.

PREDETERMINED MOTION TIME SYSTEM (PMTS):

A **Predetermined Motion Time System (PMTS)** may be defined as a procedure or method which analyses any manual activity/human motion in terms of the basic or fundamental motions required to perform it. Each of these motions is assigned to a previously established standard time value and then the timings for the individual motions are synthesized to obtain the total time needed for performing the activity.

PMTS is a work measurement technique which comes next to synthetic times. They are more refined and accurate than the synthetic times because they are obtained gradually with more accuracy and often used as a source of synthetic time data.

PMTS technique is used mostly for jobs, which are planned for future. However, it can also be used for current jobs as an alternative to time study.

PMTS is better than motion studies because it gives the detailed analysis of the motion, and it fixes the standard time for doing that motion.

Applications of PMTS are for

1) Determination of job time standards.
2) Comparing the times for alternative proposed methods so as to find the economics of the proposals prior to production run.
3) Estimation of manpower, equipment and space requirements prior to Setting up the facilities and start of production.
4) Developing tentative work layouts for assembly lines prior to their working in order to minimize the amount of subsequent re–arrangement and re–balancing.

5) Checking direct time study results.

A number of PMTS are in use, some of which have been developed by individual organizations for their own use, while other organizations have developed and publicized for universal applications.

Some commonly used PMT systems are:

- Work factor (1938)
- Method Time Measurement (1948)
- Basic Motion Time (1951)
- Dimension Motion Time (1954)

PROCEDURE OF PMTS:

a. Study the complete operation cycle few times.

b. Observe and record the activities of one hand at a time.

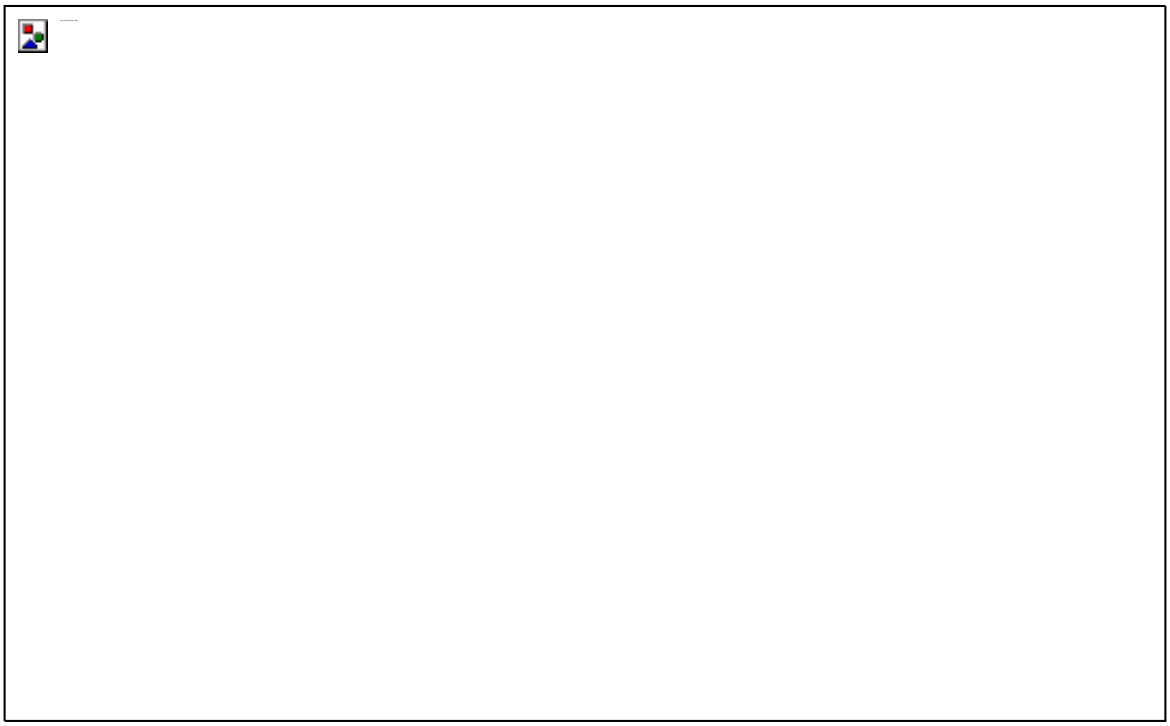
c. Record only few symbols at a time.

d. Recording should be started at a point of time that can be easily distinguished. For examples activity of picking up the such work piece at the beginning of cycle of work is a good point from which recording the movements should be started,

e. Care should be taken that no activity is left while recording, as it\will affect the method study badly.

f. Combinations of operations and transport should be avoided, unless they actually occur at the same time.

A two hand process chart for nut and bolt assembly is shown in Fig. 18.13.



OBJECTIVES OF PMTS:

The predetermined lime systems have been successfully applied to:

a. Determine job time standards.

b. Compare the times for alternative, proposed methods so as to determine the economics of the proposals before the production runs or other way round fabrication/ production of equipment to be employed.

c. To estimate the manpower, equipment and space requirements before production or prior to Setting up of facilities.

d. To develop tentative layouts for assembly lines before the work starts so as to minimize the investment on subsequent rearrangement and rebalancing etc.

e. For improving and modifying work methods before stating the work on the job.

f. To set time standards for various jobs.

g. To provide a basis for estimation of labour cost and wage plans.

h. To facilitate training of the workers and supervisory staff.

i. To utilize for timing of those short and repetitive motion which are difficult to be measured by stop watch.

TECHNIQUE /DEVELOPMENT OF A PMT SYSTEM:

It consists following steps:

a. In order to avoid the inaccuracies being introduced by use of human element, the technique used to build PMTS data does not measure element time by a stop watch.

b. It is assumed that all manual tasks in industries consists of certain basic human movements such as move, reach, engage or disengage etc. which are common in almost all jobs.

c. The average time taken by the (normal) industrial workers to perform a basic activity/ movement is practically constant.

Taking into consideration the facts mentioned above, the various steps involved in collecting PMTS data are as follows:

(1) Select a large number of workers performing various activities or doing varieties of jobs under normal working conditions in industrial units.

(2) Perform micro motion study i.e. record the job operations on a movie film.

(3) After analysing the film, note down the time taken to complete each element and compile the data in the form of a table.

That point to be noted is that the jobs are selected in such a way that they involve most of the common basic activities/motions and are worked under different Set of conditions by workers of different ages and with other different characteristics.

Once the tables/charts for various basic activities/motions are ready, the normal time for any new job can be determined by breaking the job into its basic motions, noting time for each movement from charts and adding up the time values for all the basic movements involved in the job. In this way standard time may be obtained by adding proper allowances to normal time.

SELECTION OF A PARTICULAR PMT SYSTEM:

The following factors are considered while selecting a particular PMT system for application to a particular industry:

1. **Cost of Installation:** The cost of getting experts for applying the system under consideration constitutes the cost of installation.
2. **Operational Cost:** This is determined by the length of time required to Set a standard by the systems.
3. **Level of Performance of the System:** The level of performance, contained in the system under consideration may be different from the normal performance in the industry where it is to be utilized. However, this problem could be solved by calibration which is nothing but multiplication of the times given in the charts by calibration factor (some constant) or by application of an adjustment allowance.
4. **Consistency of Standards:** The vital factor to be considered is consistency of standards Set by a system on different jobs. The system can be utilized for this on a trial basis on a Set of operations in the industrial unit and examined for consistency among them.
5. **Nature of Operation:** Best results can be achieved if the type and nature of operations in the plant are resembling the nature land type of operations being studied for developing the system under consideration.

USES OF PMTS:

Most of the uses have been minted while explaining the advantages. Their uses are classified under the two heads i.e. work methods and work measurement.

USES IN WORK METHODS:

1. Existing methods improvement.
2. Evaluation of proposed methods in advance of actual production.
3. Evaluation of design of tools, jigs and equipment etc.

4. Aiding in design of production.
5. Aiding in training operators.
6. Training members of the staff to become motion conscious.

USES IN WORK MEASUREMENT:

1. Establishing time standards.
2. Completion of standard data formulas for specific classes of work.
3. Checking standards established by time study.
4. Auditing time standards.
5. Balancing Production lines.
6. Estimating labour costs.

PMTS POSSESSES THE FOLLOWING ADVANTAGES:

i. No timing is required so it eliminates in accuracies associated with stop watch time study.

ii. The use of PMT eliminates the requirement of troublesome and controversial performance rating. So performance rating is not required.

iii. The use of PMTS, force the analyst to be method conscious and to take care of method in detail. This sometimes help's to further improve the method.

iv. Since times can be calculated before starting the work, this procedure is useful in methods design, equipment selection and design and production planning and control.

v. They are an excellent training technique.

vi. Once the analysts of an organization are familiar, they can be quickly applied.

vii. The basic times determined with the use of PMT system are relatively more consistent.

viii. Time standard for a job can be arrived at without going to the workplace.

ix. The time and cost associated with finding the standard time for a job is considerably reduced.

LIMITATIONS OF PMTS:

(1) PMTS can deal manual motions of an operation only.

(2) They are not economical for non-repetitive operations.

(3) They cannot be applied to restricted work (refer to process time studies).

(4) PMTS's are restrictive in nature because they have been built on data taken from particular operations and thus PMTS provides better results if applied to that type of work/operation only.

(5) All categories of motions have not been taken into consideration while collecting PMTS data.

(6) The need of trained personnel. Although PMT System eliminates the utilization of rating quite a bit of judgment is still essentially exercised at various stages.

MICRO–MOTION STUDY:

Micro–motion study, which was originated by **Frank B. Gilbreth,** is one of the most exacting forms of work analysis available for job improvement.

"Micro Motion Study is a technique of recording and analysing the timing of basic elements of an operations with the objective of achieving the best method of performing the operation."

It consists of taking motion pictures of the operation with a clock in the picture or with a video camera running at a known speed.

It is an analysis technique making use of motion pictures (or videotape) taken at a constant and known speed. The film becomes a permanent record of both the method being used and the time consumed in doing the work.

Although micro–motion study formerly made use of motion pictures, very few companies today are using them. As indicated earlier, videotape equipment has been developed so extensively that it has virtually supplanted the use of the motion picture camera. Further it is so cheap and easy to use that it makes the older approach archaic.

Micro–motion study provides a valuable technique for making minute analyses of those operations that are short in cycle, contain rapid movements, and involve high production over a long period of time. Thus it is very useful in analysing operations such as the sewing of garments, assembly of small parts and similar activities.

PURPOSES OF MICRO–MOTION STUDY:

- To study the nature and path of movements for obtaining the elements of an operation.
- To study the activities of the machine and the operator.
- To impart training to the workers or operators regarding motion–economy so that unnecessary movement by the workers may be avoided.
- To study the relationship between the activities of operator and the machine.
- To keep permanent record of the most efficient way of performing a task for future reference.
- To obtain motion time data for developing synthetic time standards for various elements.
- For carrying out research in the field of method and time study.

ADVANTAGES OF MICRO MOTION STUDY:

It has the following important advantages:

3. It provides a permanent record of motion study on films.
4. A large number of operators can see the procedure at any time even after the completion of motion study work.
5. Films can easily reveal the difference between the present and the proposed technique.
6. Films can be demonstrated to large work force at any desired speed.
7. It provides very accurate time for each operation or motion in comparison to stop watch time study.
8. It helps in making detailed and accurate analysis of the prevailing technique.

METHODS–TIME MEASUREMENT (MTM):

"MTM" stands for Methods–Time Measurement. It is a procedure for improving methods and establishing time standards by recognizing, classifying, and describing the motions used or required to perform a given operation and assigning pre–determined time standards to these motions.

MTM evolved into a dynamic family of systems. It is continuing to grow and meet more needs of its practitioners and users. It has developed from a single system of work measurement and analysis to a family of systems that meets the varied demands of different users.

This system is defined as a procedure which analyses any manual operation or method into basic motions require to perform it, and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made.

The basic **MTM data was developed by H B Maynard, J L Schwab and G J Stegemerten** of the Methods Engineering Council during a consultancy assignment at the Westinghouse Brake and Signal Corporation, USA in the 1940's. This data and the application rules for the MTM system were refined, extended, defined, industrially tested and documented as a result of further work in later years.

WORK FACTOR SYSTEM:

ERGONOMICS INTRODUCTION

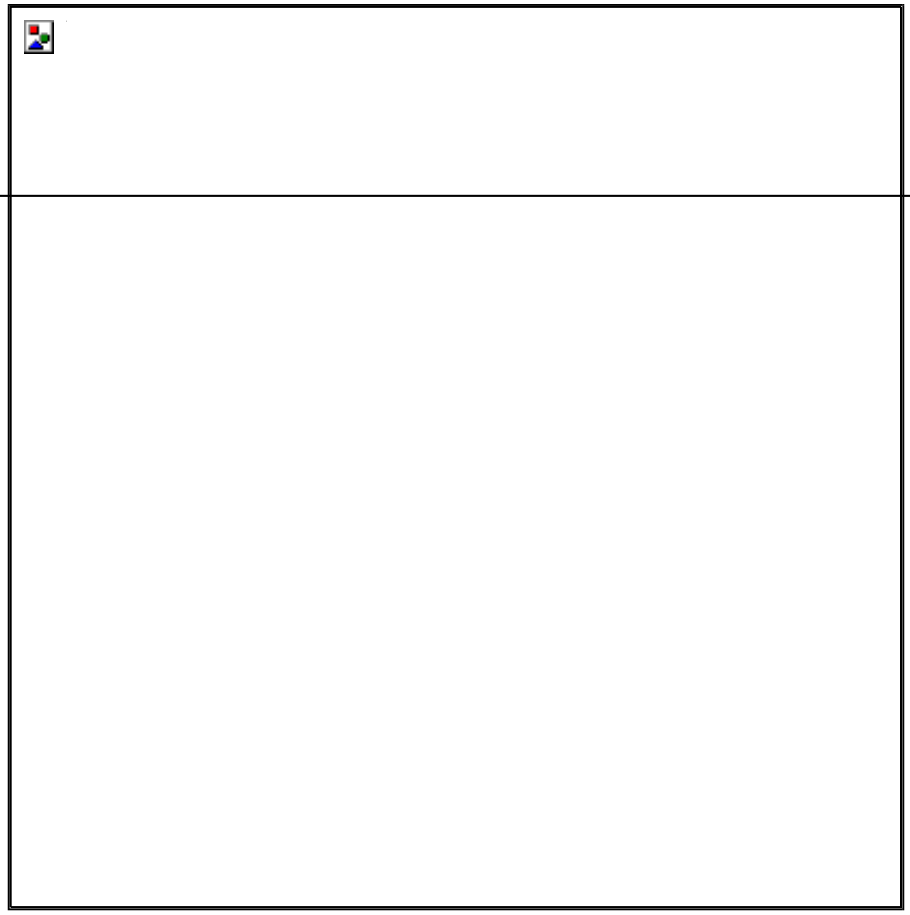
- **Webster: ergonomics:** An applied science concerned with designing and arranging things, people use so that the people and things interact most efficiently and safely.
- **Literal definition:–**Ergon (work) + Nomos (rules or habits) = "The rules of work.

DEFINITION:

The practice of adapting products and processes to human characteristics and capabilities in order to improve people's well–being and optimize productivity.

Simplest Definition: "Fitting the job to the worker"

Scientific discipline that studies the interaction between humans and the environment i.e. the person and their workstation.



Designing the job to match the worker rather than matching the worker to the job

Ergonomics covers all aspects of a job, from the physical stresses it places on joints, muscles, nerves, tendons, bones and the like, to environmental factors which can effect hearing, vision, and general comfort and health.

"Ergonomics applies information about human behaviour, abilities and limitations and other characteristics to the design of tools, machines, tasks, jobs and environments for productive, safe, comfortable and effective humanuse"

ERGONOMIC PRINCIPLES THAT CONTRIBUTE TO GOOD WORKPLACE DESIGN:

The goal for the design of workplaces is to design for as many people as possible and to have an understanding of the Ergonomic principles of posture and movement which play a central role in the provision of a safe, healthy and comfortable work environment. Posture and movement at work will be dictated by the task and the workplace, the body's muscles, ligaments and joints are involved in adopting posture, carrying out a movement and applying a force. The muscles provide the force necessary to adopt a posture or make a movement. Poor posture and movement can contribute to local mechanical stress on the muscles, ligament and joints, resulting in complaints of the neck, back, shoulder, wrist and other parts of the musculoskeletal system.

S.NO.	ERGONOMIC PRINCIPLE	DESCRIPTION
1	Joints must be in a neutral position	In the neutral position the muscles and ligaments, which span the joints, are stretched to the least possible extent
2	Keep work close to the body	If the work is too far from the body, the arms will be out stretched and the trunk bent over forwards
3	Avoid bending Forward	The upper part of the body of an adult weighs about 40kgon average. The further the trunk is bent forwards, the harder it is for the muscles and ligaments of the back to maintain the upper body in balance
4	A twisted trunk strains the back	Twisted postures of the trunk cause undesirable stress to the spine
5	Alternate posture as well as movements	No posture or movement should be maintained for along period of time. Prolonged postures and repetitive movements are tiring.
6	Avoid excessive reaches	It is necessary to limit the extent of forward and sideways reaches to avoid having to bend over or twist the trunk
7	Avoid carrying out tasks above shoulder level	The hands and elbows should be well below shoulder level when carrying out a task
8	Limit the weight of a load that is lifted	There are guidance weight limits for both males and females detailed in Figure 2of this document
9	Use mechanical aids	Many lifting accessories are available to help lift and move loads
10	Avoid carrying loads with one hand	When only one hand is used to carry a load, the body is subject to mechanical stress
11	Use transport accessories	There are a large number of accessories such as roller conveyors, conveyor belts, trolleys and mobile raising platforms, which eliminate or reduce manual handling.

FLOW PROCESS CHART:

A flowchart is a type of diagram that represents an algorithm, workflow or process. The flowchart shows the steps as boxes of various kinds, and their order by connecting the boxes with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analysing, designing, documenting or managing a process or program in various fields.

A flowchart is a graphic representation of how a process works, showing at a minimum sequence of steps. Several types of flowcharts exist: the most simple (high level), a detailed version (detailed), and one that also indicates the people involved in the steps (deployment or matrix).

A flowchart is a picture of the separate steps of a process in sequential order.

Elements that may be included are: sequence of actions, materials or services entering or leaving the process (inputs and outputs), decisions that must be made, people who become involved, time involved at each step and/or process measurements.

WHEN TO USE A FLOWCHART:

- To develop understanding of how a process is done.
- To study a process for improvement.
- To communicate to others how a process is done.
- When better communication is needed between people involved with the same process.
- To document a process.
- When planning a project.

FLOWCHART BASIC PROCEDURE:

Materials needed: sticky notes or cards, a large piece of flipchart paper or newsprint, marking pens.

- Define the process to be diagrammed. Write its title at the top of the work surface.
- Discuss and decide on the boundaries of your process: Where or when does the process start? Where or when does it end? Discuss and decide on the level of detail to be included in the diagram.
- Brainstorm the activities that take place. Write each on a card or sticky note. Sequence is not important at this point, although thinking in sequence may help people remember all the steps.
- Arrange the activities in proper sequence.
- When all activities are included and everyone agrees that the sequence is correct, draw arrows to show the flow of the process.
- Review the flowchart with others involved in the process (workers, supervisors, suppliers, customers) to see if they agree that the process is drawn accurately

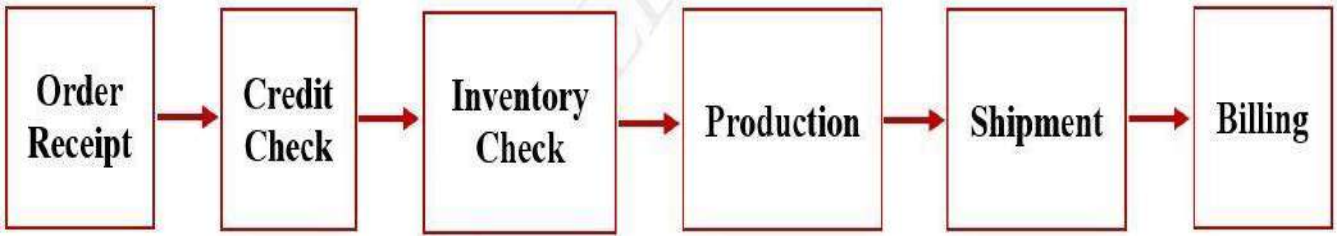
The flowchart is a means to visually present the flow of data through an information processing systems, the operations performed within the system and the sequence in which they are performed. In this lesson, we shall concern ourselves with the program flowchart, which describes what operations (and in what sequence) are required to solve a given problem. The program flowchart can be likened to the blueprint of a building. As we know, a designer draws a blueprint before starting to construct a building. Similarly, a programmer prefers to draw a flowchart prior to writing a computer program. As in the case of the drawing of a blueprint, the flowchart is drawn according to defined rules and using standard flowchart symbols

COMMONLY USED SYMBOLS IN DETAILED FLOWCHARTS:

S. No.	Symbols	Description
1		One step in the process – The step is written inside the box.
2		Direction of flow from one step or decision to another.
3		Decision making – Decision based on a question. The question is written in the diamond. More than one arrow goes out of the diamond, each one showing the direction the process takes for a given answer to the question. (Often the answers are "yes" and "no.")
4		Delay or wait
5		Link to another page or another flowchart. The same symbol on the other page indicates that the flow continues there.
6		Input or output
7		Document
8		Alternate symbols for start and end points

A Simple flowchart representing a process for dealing with a non–functioning lamp.

Flowchart Examples: High–Level Flowchart for an Order–Filling Process.



DETAILED FLOWCHART:

STRING DIAGRAM:

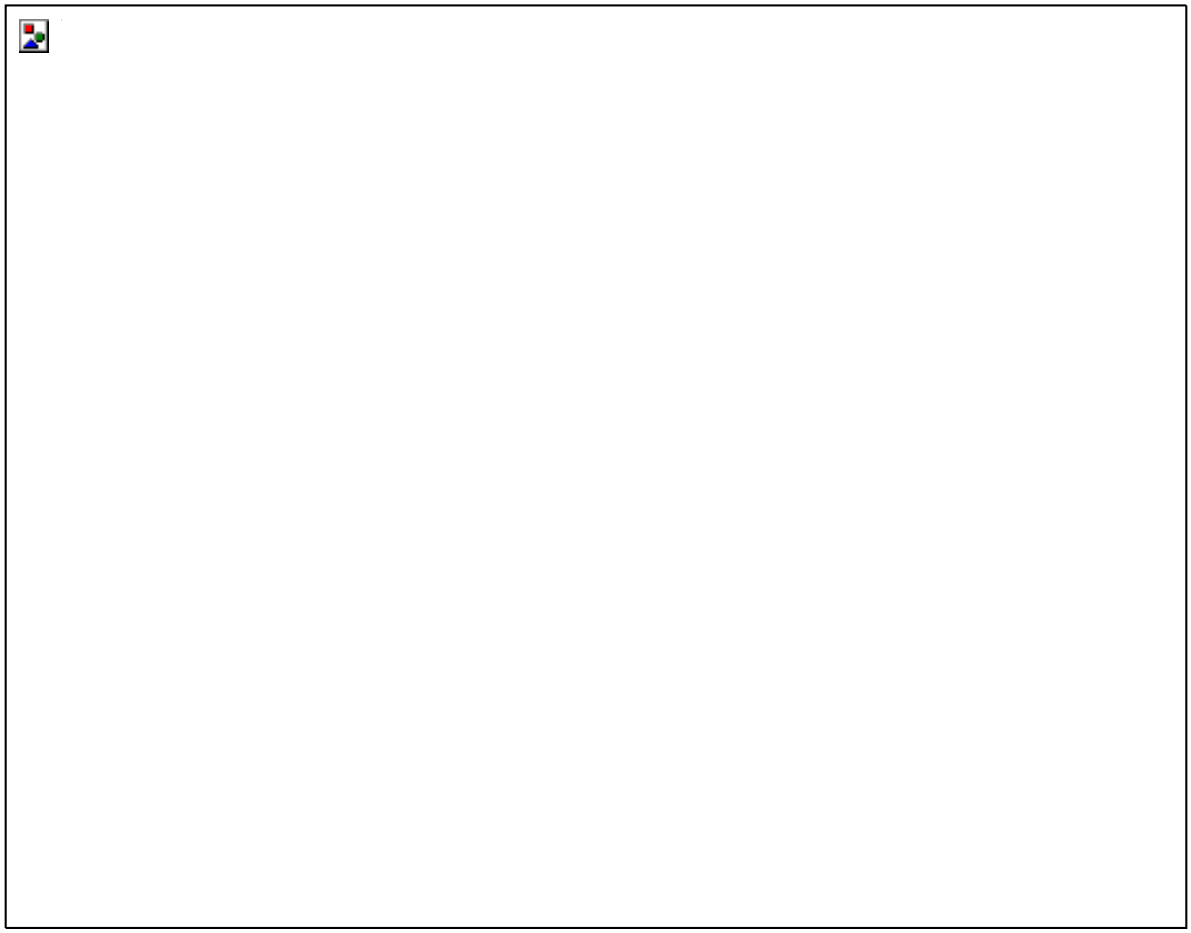
The **String Diagram** is a simple tool for analysing and designing work spaces such that movement can be minimized. The basic diagram simply consists of a map of the work area, with the actual movements drawn on top.

The term 'String Diagram' comes from the way the diagram may be created with a scale drawing, pins and a piece of string (you can then measure the string to see how far the movements are).

PROCEDURE AND PURPOSE OF STRING DIAGRAM:

String diagram is one of the useful and simplest techniques of method study. It can be defined as a scale model on which a thread is used to trace the path or movements of man and materials during a specified sequence of events.

It can also be stated that string diagram in a special form of flow diagram. As a thread is used to measure distance, it is necessary that the string diagram should be drawn up to scale. The same is not necessary in case of flow diagram. A typical string diagram is drawn in Fig.



A brief procedure for the construction of string diagram in given as follows:

a. Study and record the complete information about the movement of various resources.
b. Draw a scale layout of the shop area and mark various features such as machinery, work benches, stores etc.

c. Mark and insert panel pins at all workstations between which the journeys are made. More pegs/pins may be stretched in between the facilities to trace more or less the actual path followed by men and materials.

d. A continuous colored unstrechable string, taken from the first to last warned to trace the path followed by operators or materials. Use strings/ threads of different colours if the movement of more subjects is being shown so that their movements are easily recognized and distinguished.

e. Remove the string to measure their lengths which approximately gives distances travelled by a worker or a machine or the material.

Like the flow diagram. It is also used to supplement a flow–process chart. Generally the work study man proceeds to follow the worker in whom he is interested or whose movements he wants to record. If area of the working is small, work study man can simply sit on a place and can notice the various movements of worker from there.

This recording of movements continues till the work study man thinks is that he has recorded all the movements. Totally misleading rewets are produced with insufficient data.

Examination of the diagram and development of new layout is done in same manner as we have earlier explained in case of flow diagrams. This can be done by moving the thread around the pins in the various positions. Length of thread left is subtracted from the original length of thread. Procedure is repeated till the maximum length of left thread in obtained.

A string diagram is a useful aid for following purposes (Benefits of String Diagram):

1. It represents the record of an existing Set of conditions and thus helps the method engineer in visualizing the actual situation.
2. It indicates complex movements, back tracking, congestion, bottle necks and over and underutilized paths on the shop floor.
3. It is an aid for comparison between different layouts or methods of doing a job as far as the distances moved are involved.
4. It helps in tracing existing paths of movement for incorporating necessary modifications, if any.
5. It is prefixed when movements are not regular as far as frequency and distance moved are concerned.
6. Indicates the pattern of movements and thus helps in deciding the most economical routes to perform a particular operation.

THERBLIGS:

The therblig is used in the study of motion economy in the workplace. A workplace task is analyzed by recording each of the therblig units for a process, with the results used for optimization of manual labor by eliminating unneeded movements.

The **word therblig** was the creation of **Frank Bunker Gilbreth and Lillian Moller Gilbreth**, American industrial psychologists who invented the field of time and motion study. It is a reversal of the name Gilbreth, with 'th' transposed.

THE BASIC MOTION ELEMENTS/KINDS OF THERBLINGS:

A basic motion element is one of a Set of fundamental motions required for a worker to perform a manual operation or task. Therbligs are 18 kinds of elemental motions used in the study of motion economy in the workplace each describing a standardized activity.

1) **Transport Empty** [unloaded] (TE): Receiving an object with an empty hand. (Now called "Reach")
2) **Grasp** (G): Grasping an object with the active hand.
3) **Transport Loaded** (TL): Moving an object using a hand motion.
4) **Hold** (H): Holding an object.
5) **Release Load** (RL): Releasing control of an object.
6) **Preposition** (PP): Positioning and/or orienting an object for the next operation and relative to an approximation location.
7) **Position** (P): Positioning and/or orienting an object in the defined location.
8) **Use** (U): Manipulating a tool in the intended way during the course working.
9) **Assemble** (A): Joining two parts together.
10) **Disassemble** (DA): Separating multiple components that were joined.
11) **Search** (Sh): Attempting to find an object using the eyes and hands.
12) **Select** (St): Choosing among several objects in a group.
13) **Plan** (Pn): Deciding on a course of action.
14) **Inspect** (I): Determining the quality or the characteristics of an object using the eyes and/or other senses.
15) **Unavoidable Delay** (UD): Waiting due to factors beyond the worker's control and included in the work cycle.
16) **Avoidable Delay** (AD): Waiting within the worker's control which causes idleness that is not included in the regular work cycle.

17) **Rest** (R): Resting to overcome a fatigue, consisting of a pause in the motions of the hands and/or body during the work cycles or between them.

18) **Find** (F): A momentary mental reaction at the end of the Search cycle. Seldom used.

PROBLEMS

1) Assuming that the total observed time for an operation of assembling an electric switch is 1.00 min. If the rating is 120%, find normal time. If an allowance of 10% is allowed for the operation, determine the standard time.

Solution:

Given data:

Observed time (or) Selected Time = 1.00 Min

Rating = 120%

Allowance = 10%

To Find: Standard Time?

We Know:

Standard Time = Normal Time + Allowances

As we know that Normal Time =

=

Allowance @10% =

=

Standard Time = Normal Time + Allowances

= 1.20 + 0.12 = 1.32 min

2) An operator manufactures 50 jobs in 6 hours and 30 minutes. If this time includes the time for Setting his machine. Calculate the operator's efficiency, Standard time allowed for the job was:

Setting Time = 35 min.

Production time per piece = 8 min

Solution:

Given data:

Set up time = 35 min

Time Taken per Piece = 8 min

No. of pieces produced = 50

Actual time taken by operator for manufacturing of 50 pieces = 6 hours and 30 minutes = 390 min

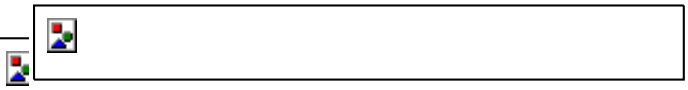
To Find: Efficiency of Operator?

As we know that

Standard Time = Set up time + Time per piece × No. of Pieces produced.

∴ Standard Time for manufacturing 50 jobs = 35 + 8 × 50

= 435 min = 7 Hours and 15 min.



=

= 111.5 %

∴Efficiency of operator = 111.5%

3) Following data were obtained by a work study Man from a study conducted by hours.

i. Maintenance time

a) Get out and put away tools = 12.0 min/day

b) Cleaning of machine = 5.0 min/day

c) Oiling of machine = 5.0 min/day

d) Replenish coolant supply = 3.0 min/day

ii. Interruption

a) Interruption of foreman = 5.0 min/day

b) Interruption of porter etc. = 4.0 min/day

iii. Delay time due to power failure etc. = 6.0 min/day

iv. Personal Time = 20.0 min/day

Calculate total allowances, total available cycle time & production hours, considering a working day of 8 hours.

Solution:

Given Data:

i. Maintenance time

a) Get out and put away tools = 12.0 min/day

b) Cleaning of machine = 5.0 min/day

c) Oiling of machine = 5.0 min/day

d) Replenish coolant supply = 3.0 min/day

ii. Interruption

a) Interruption of foreman = 5.0 min/day

b) Interruption of porter etc. = 4.0 min/day

iii. Delay time due to power failure etc. = 6.0 min/day

iv. Personal Time = 20.0 min/day

v. Total working day = 8 hours (480 min.)

To Find:

1. Total Allowances?
2. Total Available Cycle Time?
3. Production Hours?

We Know that:

1. Total Allowances (Sometimes also Known as station time) = Total Maintenance time + Interruption Time + Delay time + Personal Time
2. Total Available Cycle Time = Total work period – Total Allowances
3. Productive Hours = Time available/ No. of Hours

Now

1. Total Allowances = Total Maintenance time + Interruption Time + Delay time + Personal Time

   = (12.0 + 5 + 5 + 3.0) + (5.0 + 4.0) + 6.0 + 20.0

   = 25.0 + 9.0 + 6.0 + 20.0

∴ Total Allowances **= 60.0 min per day.**

2. Total Available Cycle Time = Total work period – Total Allowances

   = 480 – 60

∴ Total Available Cycle Time **= 420 min/day.**

3. Productive Hours = Time available/ No. of Hours.

   = 420/8

∴ Productive Hours **= 52.5 min**

4) Find out the standard time using the following data:

Average time for machine elements = 6 min

Average time for manual elements = 4 min

Performance rating = 110%

Allowances = 10%

Solution:

Given data:

Average time for machine elements = 6 min

Average time for manual elements = 4 min

Performance rating = 110%

Allowances = 10%

To Find: Standard Time?

We Know:

Standard Time= Normal Time + Allowances

As we know that Normal Time =

=

=

Standard Time = Normal Time + Allowances

= 10.4 (1 + 0.1) = 11.44 min

IMPORTANT QUESTIONS IN UNIT – III FROM PREVIOUS QUESTION PAPERS

1. Define ergonomics. Differentiate between static and dynamic ergonomics. Describe the ergonomic considerations in design of any system. [15M] April – 2015 Set 1
2. Define operations management. Explain the nature and scope of operations management. [8M] May/June – 2015 Set 1
3. Define the term work study and state its objectives. [7M] May/June – 2015 Set 1
4. Define production. Discuss the different types of production. [8M] May/June – 2015 Set 2
5. What are the objectives of time study and how is it organized? [7M] May/June – 2015 Set 2
6. What is PMTS? What are the different types of PMTS and explain them? [7M] May/June – 2015 Set 3
7. Explain the procedure, advantages and disadvantages of work sampling.[8M] May/June – 2015 Set 3
8. Define Ergonomics? Discuss the principles of ergonomics of posture and movement? [7M] May/June – 2015 Set 4
9. Define string diagram? How it is constructed? List out the advantages and disadvantages of string diagrams? [8M] May/June – 2015 Set 4
10. Discuss the steps involved in work study. [7M] Dec – 2015 Set 1
11. What are Therbligs? Explain their importance. Give their name, explanation, abbreviation and symbol.

    Explain the factors governing the location of a plant. [8M] Dec – 2015 Set 1
12. Explain the term PMTS. [4M] April – 2016 Set 1
13. State the differences between method study and work measurement with their objectives. [8M] April – 2016 Set 1
14. Explain the need and procedure for conducting work sampling study. [8M] April – 2016 Set 1
15. Explain the importance of Ergonomics. [4M] April – 2016 Set 2
16. Explain the steps followed in method study of job process. [8M] April – 2016 Set 2
17. What is process Chart? Explain different types of process chart with relevant sketches. [8M] April – 2016 Set 2
18. Explain MTM. [4M] April – 2016 Set 3
19. What is time study? Describe the steps involved in time study. [8M] April – 2016 Set 3
20. Explain how a high productive design of a work place layout can be made with the concept of Ergonomics motion economy. [8M] April – 2016 Set 3
21. What is Therbligs? [4M] April – 2016 Set 4
22. Explain how micro–motion study is performed. [8M] April – 2016 Set 4

23. Describe briefly the different technique of rating used in connection with work study of an operator's performance in a labor intensive industry. [8M] April – 2016 Set 4
24. What are the advantages of method study? [8M] Nov/Dec – 2016 Set 1
25. Explain the methodology of MTM. [7M] Nov/Dec – 2016 Set 1
26. What is work sampling and describe when it is used. [4M] Nov/Dec – 2016 Set 1
27. What are the techniques of work study and explain its significance. [8M] Nov/Dec – 2016 Set 1
28. What are the tools for recording information about method study? [8M] Nov/Dec – 2016 Set 1
29. What do you understand by 'work measurement' and elaborate the important techniques involved in work measurement? [8M] April – 2017 Set 1
30. What are the benefits of time study? [7M] April – 2017 Set 1
31. With neat sketch briefly explain string diagram. [4M] April – 2017 Set 1
32. Name the various recording techniques used in method study. Give the various symbols used in recording techniques with their meaning. [8M] April – 2017 Set 1
33. Explain the objectives of time study. [8M] April – 2017 Set 1
34. What is micro motion study? Explain. [3M] April – 2017 Set 2
35. Explain the utility of outline process chart in method study. Differentiate between outline process chary and flow process chart. [8M] April – 2017 Set 2
36. Explain the construction of a string diagram with neat sketch. [8M] April – 2017 Set 2
37. What do you understand from work sampling? Explain briefly. [4M] April – 2017 Set 3
38. What is a flow process chart? Discuss its utility for method study engineer. [8M] April – 2017 Set 3
39. Explain the objectives of micro–motion study. [8M] April – 2017 Set 3
40. What are the applications of operations management? [4M] April – 2017 Set 4
41. State and explain in brief the steps involved in method study procedure. [8M] April – 2017 Set 4
42. "Critical examination is a motive force to develop a new method". Justify. [8M] April – 2017 Set 4
43. Define operations management. Explain the nature and scope of operations management. [8M] Nov – 2017 Set 1
44. Explain the construction of a string diagram with neat sketch. [7M] Nov – 2017 Set 1
45. State the objectives of work measurement. [3M] Nov – 2017 Set 1
46. What are Therblings? List various Therblings and their use in method study. [10M] Nov – 2017 Set 1
47. Stop watch time study of an element is done on an operation, the readings were observed as follows

    0.52 0.51 0.52 0.52 0.51 0.50 0.50 0.52

    The average rating factor for the operator is 120%. Find out the Standard time, assuming allowances 20%. [6M] Nov – 2017 Set 1

48. Define work study. What are the advantages of work study? [4M] April – 2018 Set 1
49. What are flow process charts? Give their importance. [8M] April – 2018 Set 1
50. What do you understand by work measurement and elaborate the important techniques involved in work measurement? [8M] April – 2018 Set 1
51. What is method study technique? Explain its significance. [4M] April – 2018 Set 2
52. Explain in detail about travel chart? [8M] April – 2018 Set 2
53. What is PMTS? What are the different types of PMTS? Discuss the procedure involved in PMTS. [8M] April – 2018 Set 2
54. Discuss in detail about Therbligs. [4M] April – 2018 Set 3
55. What is performance rating? Explain various methods of rating. [8M] April – 2018 Set 3
56. Explain about "SIMO" chart and state its applications. [8M] April – 2018 Set 3
57. How do you estimate time by MTM method? Explain. [4M] April – 2018 Set 4
58. Discuss in detail about work factor system? [6M] April – 2018 Set 4
59. Write in detail about the applications and objectives of operations management? [10M] April – 2018 Set 4
60. Define work study. [2M] Nov – 2018 Set 1
61. Discuss the various types of production. [7M] Nov – 2018 Set 1
62. What do you understand by work measurement and elaborate the important techniques involved in work measurement? [7M] Nov – 2018 Set 1

UNIT-4

STATISTICAL QUALITY CONTROL

SYLLABUS:

STATISTICAL QUALITY CONTROL: Quality control, its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – *X* and R – charts *X* AND *S* charts and their applications, numerical examples.

TOTAL QUALITY MANAGEMENT: Zero defect concept, Quality circles, Implementation, applications, ISO quality systems. Six Sigma - Definition, Basic concepts.

INTRODUCTION

Quality Control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer.

DEFINITION

Statistical quality control refers to the use of statistical methods in the monitoring and maintaining of the quality of products and services.

The process of applying statistical principals to solve the problem of controlling the quality control of a product or service is called statistical quality control.

MEANING AND IMPORTANCE:

Present era is the 'Era of Quality'. In this age of cutthroat competition and large scale production, only that manufacturer can survive who supplies better quality goods and renders service to-the consumers. In fact quality control has become major consideration before establishing an industrial undertaking. Proper quality control ensures most effective utilisation of available resources and reduction in cost of production.

The word quality control comprises of two words viz., quality and control. It would be appropriate to explain these two words separately to understand clearly the meaning of quality control.

According to Dr. W.K. Spriegel "The quality of a product may be defined as the sum of a number of related characteristics such as shape, dimension, composition, strength, workmanship, adjustment, finish and colour".

In the words of John D. McIIellan, "Quality is the degree to which a product conforms to specifications and workmanship standards".

It is clear from these definitions that quality refers to various characteristics of a product and their excellence. Quality is a relative term and is never absolute depending upon the use of the product and circumstances under which it is used.

SOME OF THE IMPORTANT DEFINITIONS OF QUALITY CONTROL ARE ENUMERATED AS UNDER:

"Quality control may be defined as that industrial management technique or group of techniques by means of which products of uniform acceptable quality are manufactured. It is indeed the mechanism by which products are made to measure up to specifications determined from customer's demand and transformed into sales, engineering and manufacturing requirements. It is concerned with making things right rather than the discovering and rejecting those made wrong". By — **Alford and Beatty**

"Quality control means the recognition and removal of identifiable causes and defects, and variables from the set standards". By — **J.A. Shubin.**

"Quality control is used to connote all those activities which are directed for defining, controlling and maintaining quality". By — **K.G. Lockyer.**

"Quality control is systematic control by management of the variables in the manufacturing process that affect goodness of the end-product." By — **H.N. Broom.**

"Quality control is systematic control of these variables in the manufacturing process which affect the excellence of the end product. These variables result from the application of materials, men, machines and manufacturing condition. The production system possesses those inputs to produce desirable outputs.

Only when these variables in the inputs are regulated to the extent that they do not deviate unnecessarily from the excellence of the manufacturing process as reflected in the quality of the finished product, can the control of quality be said to exist. " By — **Bethel**, **At water and Stackman**

"Quality control includes techniques and systems for the achievement of the required quality in the articles produced and for the elimination of sub-standard goods." By — **Tome, Simen and HcGill.**

"Quality control is a system of inspection, analysis and action applied to a manufacturing process so that, by inspecting a small portion of the product currently produced, an analysis of its quality can be made to determine what action is required on the operation in order to achieve and maintain the desired level of quality." By — **Joseph Manueb.**

"Quality control is a technique of scientific management which has the object of improving industrial efficiency by concentrating on better standards of quality and on controls to ensure that these standards are always maintained. It is not intended to show what is wrong with current technology, but rather to establish what can be achieved with existing methods when they are operated correctly." By — **D.J. Desmond.**

From the above mentioned definitions, it is clear that quality control is concerned with controlling the negative variables which affect the ultimate quality of a product and in a broader sense it is concerned with the performance of those activities leading to fulfilment the company's objectives.

IMPORTANCE OR BENEFITS OF QUALITY CONTROL

Some of the importance or benefits of quality control are:

1. Encourages quality consciousness.
2. Satisfaction of consumers.
3. Reduction in production cost.
4. Most effective utilisation of resources.
5. Reduction in inspection costs.
6. Increased goodwill.
7. Higher morale of employees.
8. Improved employer-employee relations.
9. Improved techniques and methods of production.
10. Effective advertisement.
11. Facilitates price fixation.
12. Increased sales.

1. **Encourages quality consciousness:** The most important advantage derived by introducing quality control is that it develops and encourages quality consciousness among the workers in the factory which is greatly helpful in achieving desired level of quality in the product.
2. **Satisfaction of consumers:** Consumers are greatly benefited as they get better quality products on account of quality control. It gives them satisfaction.
3. **Reduction in production cost:** By undertaking effective inspection and control over production processes and operations, production costs are considerably reduced. Quality control further checks the production of inferior products and wastages thereby bringing down the cost of production considerably.
4. **Most effective utilisation of resources:** Quality control ensures maximum utilisation of available resources thereby minimising wastage and inefficiency of every kind.
5. **Reduction in inspection costs:** Quality control brings about economies in inspection and considerably reduces cost of inspection.
6. **Increased goodwill:** By producing better quality products and satisfying customer's needs, quality control raises the goodwill of the concern in the minds of people. A reputed concern can easily raise finances from the market.

7. **Higher morale of employees:** An effective system of quality control is greatly helpful in increasing the morale of employees, and they feel that they are working in the concern producing better and higher quality products.
8. **Improved employer-employee relations:** Quality control develops to better industrial atmosphere by increasing morale of employees which ensures cordial employer-employee relations leading to better understanding and closeness between them.
9. **Improved techniques and methods of production:** By supplying technical and engineering data for the product and manufacturing processes, improved methods and designs of production are ensured by quality control.
10. **Effective advertisement:** Organisations producing quality products have effective advertisement. They win the public confidence by supplying those better quality products.
11. **Facilitates price fixation:** By introducing quality control measures, uniform products of same quality are produced. This greatly facilitates the problem of price fixation. One price of standard products becomes prevalent in the market.
12. **Increased sales:** Quality control ensures production of quality products which is immensely helpful in attracting more customers for the product thereby increasing sales. It is greatly helpful in maintaining existing demand and creating new demand for the product. It has been rightly pointed out that quality control is a powerful instrument with the help of which markets both at home and abroad can be expanded.

OBJECTIVES OF QUALITY CONTROL:

Following are the important objectives of quality control:

1. To establish the desired quality standards which are acceptable to the customers?
2. To discover flaws or variations in the raw materials and the manufacturing processes in order to ensure smooth and uninterrupted production.
3. To evaluate the methods and processes of production and suggest further improvements in their functioning.
4. To study and determine the extent of quality deviation in a product during the manufacturing process.
5. To analyse in detail the causes responsible for such deviation.
6. To undertake such steps which are helpful in achieving the desired quality of the product.

METHODS OR TOOLS OF QUALITY CONTROL:

Any variations in the quality of a product, i.e., standards set are mainly caused by variations in raw material, men, machines, methods, and procedures of procedures of production and inspection. In order to produce the

quality products, these variations need to be checked and controlled. There are mainly two methods of quality control.

These are:

1. Inspection:
2. Statistical Quality Control:

1. INSPECTION:

Inspection, in fact, is the common method used for quality control purposes not only in production but also in services.

As regards inspection in production, there are three important aspects involved in it:

(i) Product Inspection: As the name itself suggests, the product inspection relates to the final product sent into the market. The main purpose of product inspection is to ensure that the products sent into the market comply with the set standard for quality. In other words, it is to ensure that the product ready for sale is perfect and free of defects.

(ii) Process Inspection: Process inspection proceeds to product inspection. It is aimed at ensuring that the raw material and machines and equipment's used in the production process are of prescribed quality and mark.

Process inspection benefits the unit in two ways:

(1) It ensures the manufacturing of a quality product.

(2) It saves wastages of material by preventing process bottlenecks.

(iii) Inspection Analysis:

This is a method based on the analyses of inspections made. The conclusions derived from the inspection analyses help the entrepreneur locate the exact points in manufacturing process where faults lie. In other words, it enables the entrepreneur to identify the points at which deviations from standard set start. Quality control through Inspection Method is shown in the following Figure 1.

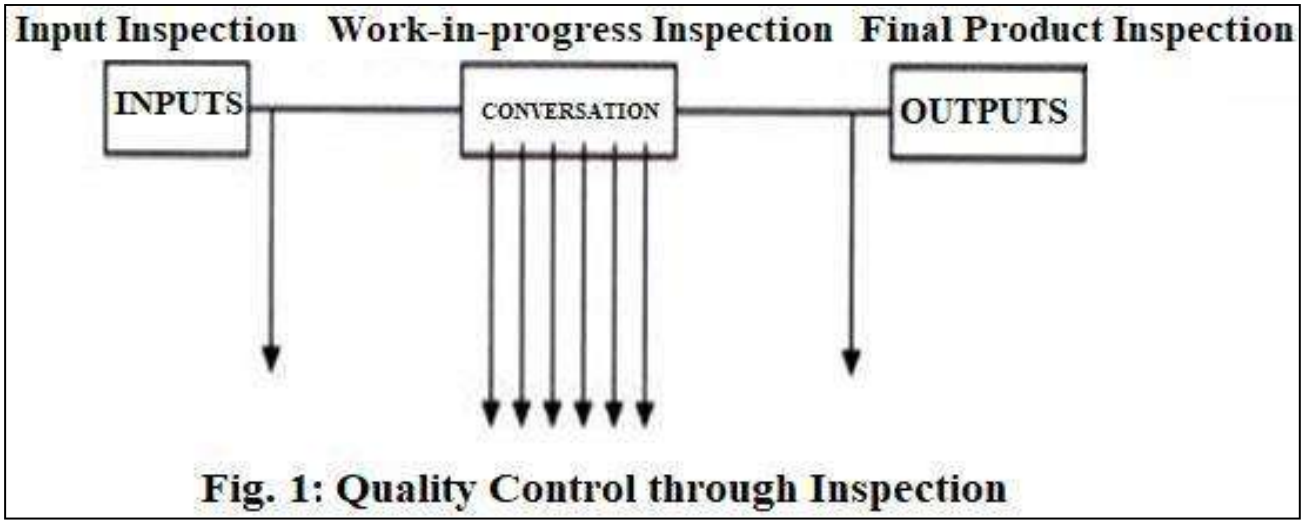


Fig. 1: Quality Control through Inspection

2. STATISTICAL QUALITY CONTROL:

It is an advanced method or technique used to control the quality of a product. This method is based on statistical techniques to determine and control the quality. Sampling, probability, and other statistical inferences are used in this method for controlling the quality of a product. It is widely used in process control in continuous process industries and in industries producing goods on a mass scale.

PRINCIPLES OF (STATISTICAL) QUALITY CONTROL:

The principles that govern the control of quality in manufacturing are:

1. Control of quality increases output of saleable goods, decreases costs of production and distribution, and makes economic mass production possible.
2. The quality of manufactured goods is variable with an upward trend under conditions of competitive manufacturing.
3. The conformance of finished product to its design specifications and standards should be accomplished by avoiding the making of non-conforming materials rather than by storing the good from the bad after manufacturing is completed.

Rice has pointed out that it is necessary to fit the organisation and procedure of quality control to the situation in each plant. To do this, certain fundamental principles of statistical Quality Control must be adhered to for success in applying these techniques to manufacturing processes. Rice has stated the principles of statically quality control:

1. Variability exists in every repetitive operation, statistical methods enable management to determine what the expected or chance variability of the process is, and thus isolates the excessive variations due to an assignable cause from those due to chance. These may then be studied for the cause and corrective steps taken.
2. Wherever like products are turned out in quantity, statistical quality control techniques are applicable.
3. A state of statistical quality control, in which an operation produces articles that remain consistently within their range of chance variation, so that no assignable or findable cause is present, is not usually found where statistical control techniques have not been used.
4. Quality must be built into a product. It cannot be introduced through inspection. In the words of W. C. Deming “not how much product, but how much acceptable product is what counts.”
5. A state of control must be established at a satisfactory quality level before maximum efficiency in the operation can be obtained. The controlled process to be satisfactory must produce a satisfactory average product as well as are that does not vary from the average more than would be expected by chance.

TECHNIQUES OF APPLYING STATISTICAL QUALITY CONTROL:

Important techniques of applying statistical quality control are:

(A) Quality Control Charts and

(B) Acceptance Sampling.

QUALITY CONTROL CHART:

The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average **(Control Limit (CL))**, an upper line for the **upper control limit (UCL)** and a lower line for the **lower control limit (LCL).** These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).

Control charts for variable data are used in pairs. The top chart monitors the average, or the cantering of the distribution of data from the process. The bottom chart monitors the range, or the width of the distribution. If your data were shots in target practice, the average is where the shots are clustering, and the range is how tightly they are clustered. Control charts for attribute data are used singly.

WHEN TO USE A CONTROL CHART?

- ❖ When controlling ongoing processes by finding and correcting problems as they occur.
- ❖ When predicting the expected range of outcomes from a process.
- ❖ When determining whether a process is stable (in statistical control).
- ❖ When analyzing patterns of process variation from special causes (non-routine events) or common causes (built into the process).
- ❖ When determining whether your quality improvement project should aim to prevent specific problems or to make fundamental changes to the process.

CONTROL CHART BASIC PROCEDURE:

- ✓ Choose the appropriate control chart for your data.
- ✓ Determine the appropriate time period for collecting and plotting data.
- ✓ Collect data, construct your chart and analyze the data.
- ✓ Look for "out-of-control signals" on the control chart. When one is identified, mark it on the chart and investigate the cause. Document how you investigated, what you learned, the cause and how it was corrected.

Out-of-control signals:

- ❖ A single point outside the control limits. In Figure 2, point sixteen is above the **UCL** (upper control limit).
- ❖ Two out of three successive points are on the same side of the centerline and farther than 2 σ from it. In Figure 2, point 4 sends that signal.
- ❖ Four out of five successive points are on the same side of the centerline and farther than 1 σ from it. In Figure 2, point 11 sends that signal.

- A run of eight in a row are on the same side of the centerline. Or 10 out of 11, 12 out of 14 or 16 out of 20. In Figure 2, point 21 is eighth in a row above the centerline.
- Obvious consistent or persistent patterns that suggest something unusual about your data and your process.
- Continue to plot data as they are generated. As each new data point is plotted, check for new out-of-control signals.
- When you start a new control chart, the process may be out of control. If so, the control limits calculated from the first 20 points are conditional limits. When you have at least 20 sequential points from a period when the process is operating in control, recalculate control limits.

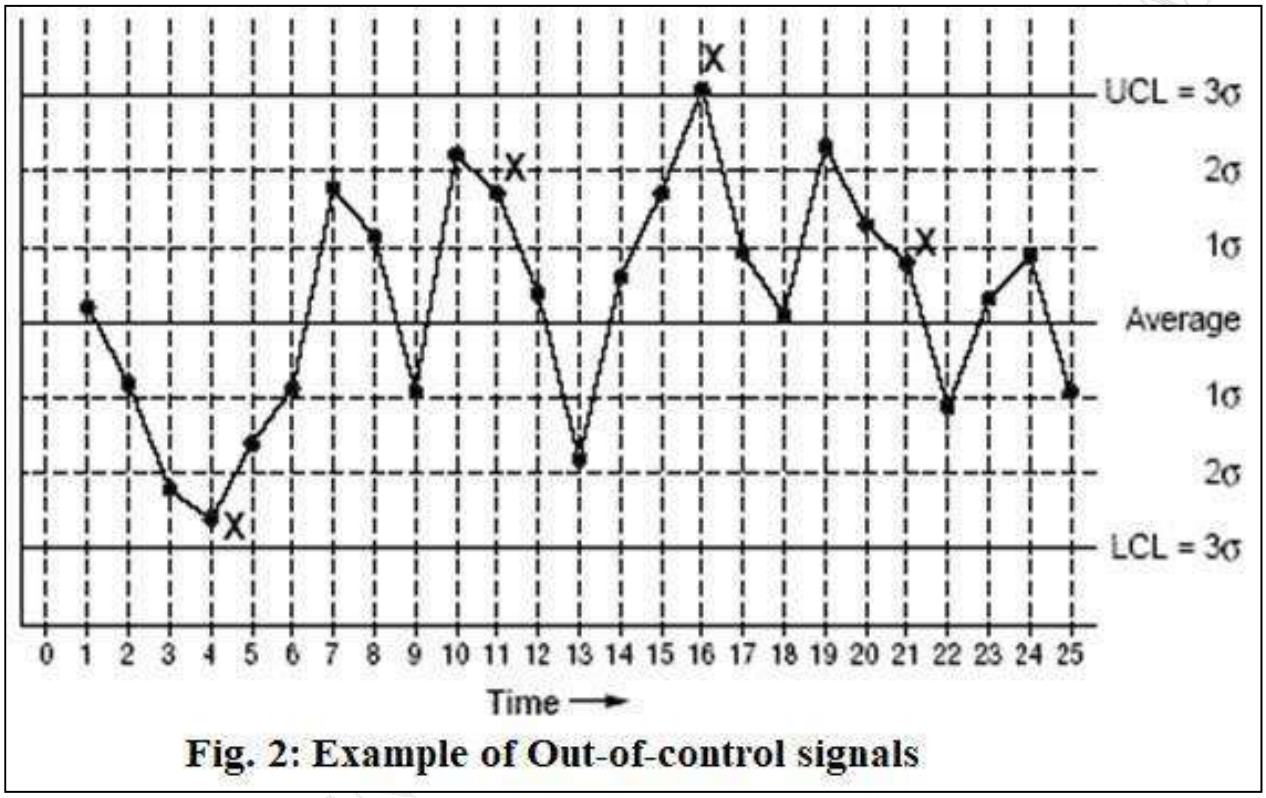


Fig. 2: Example of Out-of-control signals

Control charts show the performance of a process from two points of view. First, they show a snap-shot of the process at the moment the data are collected. Second, they show the process trend as time progresses. Process tends are important because they help in identifying the out-of-control as time progresses.

CLASSIFICATION OF CONTROL CHARTS

I. CONTROL CHARTS FOR VARIABLES:

These charts are used to achieve and maintain an acceptable quality level for a process, whose output product can be subjected to quantitative measurement or dimensional check such as size of a whole i.e. diameter or depth, length of a screw/bolt, wall thickness of a pipe etc.

These are used for measureable, quality characteristics. Let the quality characteristics of all the products be measured in subgroups. The subgroups are the samples having fixed number of items/products/component taken at random over a period of time.

The mean and the standard deviations of the quality characteristics are calculated for each sample and the following situations regarding the process may be encountered during practice.

ADVANTAGES OF CONTROL CHARTS FOR VARIABLES:

Various advantages of control charts for variables are as follows:

(1) **Ensures product quality level:** Control charts warn in time, if required rectification is done well in time the scrap and percentage rejection can be reduced, thus ensures product quality level.

(2) **The inspection work is reduced:** A control chart indicates whether the process is in control or out of control thus information about the selection of process and tolerance limits are provided.

(3) The control charts separate out the chance and assignable causes of variations in the observation thus substantial quality improvement is possible.

(4) Determines process variability and detects unusual variations taking place. So reputation of the concern/firm can be built by application of these charts.

OBJECTIVES OR PURPOSE OF CONTROL CHARTS FOR VARIABLES:

Various objectives of control charts for variables are as follows:

(1) To establish whether the process is in statistical control and in which case the variability is attributable to chance. The variability that is inherent in the process cannot be removed, unless there is a change in the basic conditions under which the production system/process is operating.

(2) It guides the production engineer in determining whether the process capability is compatible with the design specifications.

(3) To detect the trend of the observations for further planning, adjustment and resetting tools.

(4) To get prior information regarding the process, if that is likely to go out to control.

TABLE 1: Factors used for determining control limits in the $\bar{x}$ and R quality control charts.

(Based on normal distribution)

No. of Units in the sample (n)	Factor for $\bar{x}$ chart (A_2)	Factors for R chart	
		Lower Control Limit (D_3)	Lower Control Limit (D_4)
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78
11	0.29	0.26	1.74
12	0.27	0.28	1.72
13	0.25	0.31	1.69
14	0.24	0.33	1.67
15	0.22	0.35	1.65
16	0.21	0.36	1.64
17	0.20	0.38	1.62
18	.019	0.39	1.61
19	0.19	0.40	1.61
20	0.18	0.41	1.59

Procedure for Constructing -R Charts

These charts are drawn as follows:

Step-1: A number of samples of components coming out of the process are taken over a period of time, each sample consisting of a number unit's n (n is usually 4 or 5 units or some times more). The quality measurements x_1, x_2, x_3.....x_n are taken.

Step-2: For each sample the average value x of all the measurements and the range R (i.e., the difference between the highest and the lowest readings) are calculated.

Then $\bar{\bar{x}}$ and $\bar{R}$ are computed as follows:

$\bar{\bar{x}} = \frac{\bar{x_1}+\bar{x_2}+\bar{x_3}+\cdots\cdots\bar{x_m}}{m}$ (Where, m are the number of successive samples)

Step-3: After calculating x and R the control limits of the X and R charts are calculated as follows with UCL and LCL as abbreviation for upper control limit and lower control limits.

$\bar{x}$ Chart: - U.C.L. = $\bar{\bar{x}} + A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} + \frac{3\bar{R}}{d_2\sqrt{n}}$ if d_2 is given

L.C.L. = $\bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} - \frac{3\bar{R}}{d_3\sqrt{n}}$ if d_3 is given

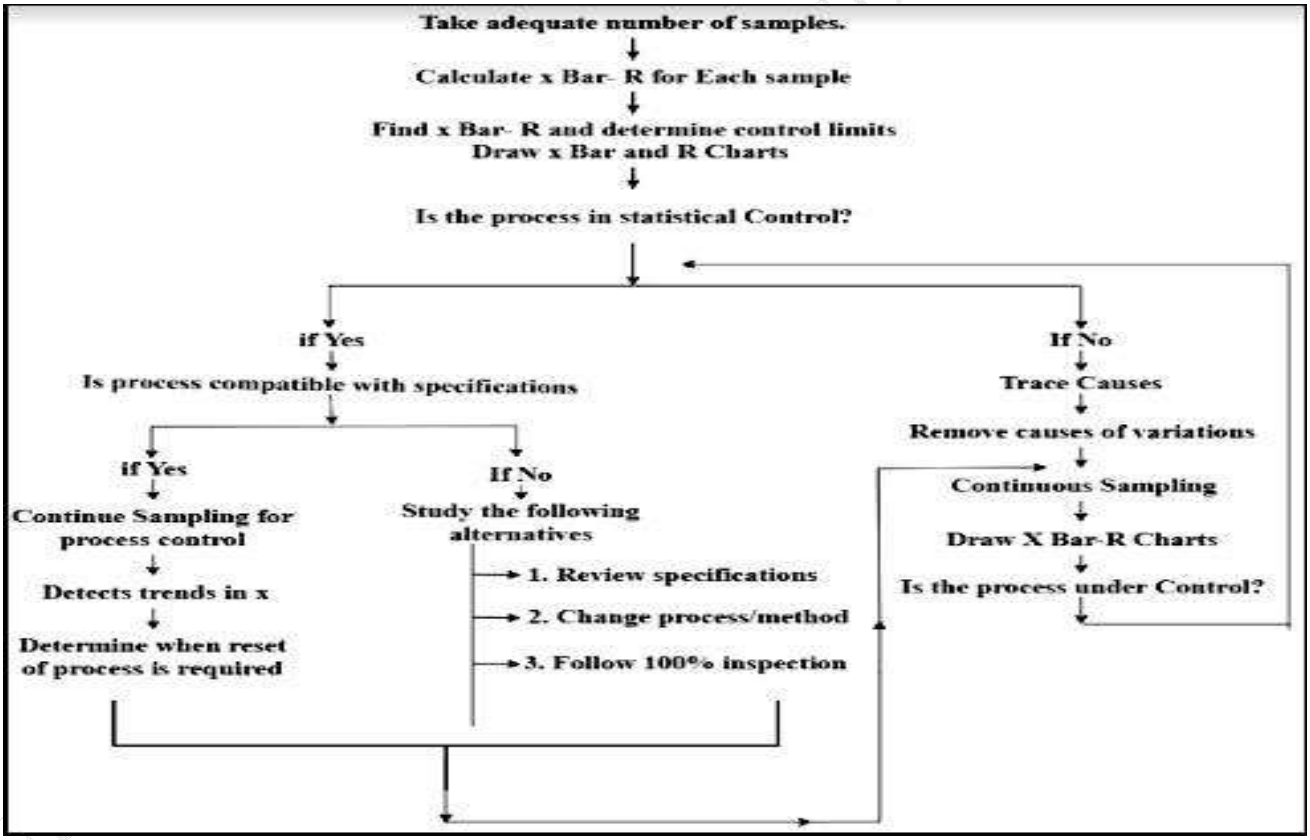
R Chart: - U.C.L. = $D_4\bar{R}$ if D_4 is given

or $= \bar{R}[\frac{1+3d_3}{d_2}]$ if d_2, & d_3 is given

L.C.L. = $D_3\bar{R}$ if D_3 is given

or $= \bar{R}[\frac{1-3d_3}{d_2}]$ if d_2, & d_3 is given

Where the factors A_2, D_4 and D_3 depend on the number of items per sample and the larger this number, the closer the limits. Table.1 gives values for these factors for various sample sizes. As long as the X and R values for each sample are within the control limits the process is said to be in statistical control.



Control limits for $\bar{X}$-Chart

$$UCL_{\bar{X}} = \bar{\bar{X}} + A\,\bar{R}$$

$$LCL_{\bar{X}} = \bar{\bar{X}} - A\,\bar{R}$$

Control limits for R-Chart

$$UCL_R = B\,\bar{R}$$

$$LCL_R = C\,\bar{R}$$

Where A, B, C are different sample sizes are given in the table

Table for ABC Values

S.No.	Sample size *n*	Mean Factor A	Upper Range Factor B	Lower Range Factor C
1	2	1.88	3.27	0.00
2	3	1.02	2.57	0.00
3	4	0.73	2.28	0.00
4	5	0.58	2.11	0.00
5	6	0.48	2.00	0.00
6	7	0.42	1.92	0.08
7	8	0.37	1.86	0.14
8	9	0.34	1.82	0.18
9	10	0.31	1.78	0.22
10	11	0.29	1.74	0.26
11	12	0.27	1.72	0.28
12	13	0.25	1.69	0.31
13	14	0.24	1.67	0.33
14	15	0.22	1.65	0.35
15	16	0.21	1.64	0.36
16	17	0.20	1.62	0.38
17	18	0.19	1.61	0.39
18	19	0.19	1.60	0.40
19	20	0.18	1.59	0.41

THE STEPS IN CONSTRUCTING AN X BAR - S CONTROL CHART:

The steps in constructing the X Bar - S chart are given below. Most of the time you will use a software program to generate control charts. However, it is important to understand how the control charts are constructed and the steps in constructing them.

1. Gather the data.

Select the subgroup size (n). Typical subgroup sizes for an X Bar - S chart are 10 or more. However, you can use the X Bar - S chart with any size subgroup of two or more. The concept of rational subgroup should be considered. The objective is to minimize the amount of variation within a subgroup. This helps you "see" the variation in the averages chart easier.

Select the frequency with which the data will be collected. This will be part of the rational subgrouping. Time is always important in taking data and in interpreting the data. Data should be collected in the order in which they are generated (in most cases).

Select the number of subgroups (k) to be collected before control limits are calculated. You can start a control chart with only 5 subgroups. You will need to recalculate the averages and control limits for each new subgroup until you have at least twenty subgroups of data.

For each subgroup, record the individual sample results. For each subgroup, calculate the subgroup average (X): where X1, X2, etc. are the individual sample results and n is the subgroup size:

$$\overline{X} = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + ... + X_n}{n}$$

For each subgroup, calculate the subgroup standard deviation:

2. Plot the data.

Select the scales for the x and y axes for both the X Bar and S charts

Plot the subgroup standard deviations (s) on the s chart and connect consecutive points with a straight line.

Plot the subgroup averages on the X chart and connect consecutive points with a straight line.

3. Calculate the overall process averages and control limits.

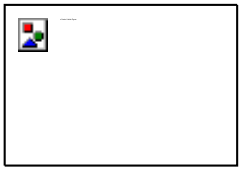
Calculate the average standard deviation (s), where s1, s2, etc. are the standard deviations for subgroups 1, 2, etc. and k is the number of subgroups:

Plot s on the s chart as a solid line and label.

Calculate the overall process average, where X_1, X_2, etc. are the subgroup averages for subgroups 1, 2, etc:

Plot the overall process average on the X chart as a solid line and label.

Calculate the control limits for the s chart. The upper control limit is given by UCLs. The lower control limit is given by LCLs. B4 and B3 are control chart constants that depend on the subgroup size.



Plot the control limits on the chart as dashed lines and label.

Calculate the control limits for the X chart. The upper control limit is given by UCL_X. The lower control limit is given by LCL_X. A3 is a control chart constant that depends on the subgroup size.

$$UCL_X = \overline{\overline{X}} + A_3 \overline{s}$$

$$LCL_X = \overline{\overline{X}} - A_3 \overline{s}$$

Plot the control limits on the X chart as dashed lines and label.

4. Interpret both charts for statistical control.

Always consider variation first. If the s chart is out of control, the control limits on the X chart are not valid since you do not have a good estimate of s. All tests for statistical control apply to the X chart. Points beyond the control limits, number of runs and length of runs apply to the s chart.

5. Calculate the process standard deviation, if appropriate.

If the s chart is in statistical control, the process standard deviation can be calculated as:

c4 is a control chart constant that depends on subgroup size.

If the control charts indicate that the process is in statistical control, extend the control limits into the future and monitor the process performance using these control limits. If the control charts indicated that there are special causes of variation, find the reason for the special cause of variation and remove it from the process. Once you have 20 points in a row in statistical control, recalculate the control limits based on that data, and use those limits in the future.

X Bar - S CONTROL CHART CONSTANTS for constructing the chart are given in table 1 & table 2 above.

II. CONTROL CHARTS FOR ATTRIBUTES:

These charts are used to achieve and maintain an acceptable quality level for a process whose output products are not subjected to dimensional or quantitative measurement but can be classified as good or bad or acceptable and non-acceptable.

For example surface finish of a product brightness of an item is either acceptable or not acceptable.

In inspection by variables as is done in x and R charts, actual measurement of the dimensions is required that is sometimes difficult as well as uneconomical.

There is another way of inspection also i.e., inspection by attributes. In this method actual measurements are not done, instead the number of faults or defectives are counted. The size of the defect and its location are not so important.

We can also say that the products are inspected the same way as by ‘Go’ and ‘No Go’ gauges. The products are either accepted or rejected and their actual dimensions are not measured

For example 100 fan blades are inspected out of which 12 are found to be defective so those 12 pieces are rejected.

The four most commonly used control charts for attributes are:

(1) Control charts from fraction defectives (p-charts)

(2) Control charts for number Defectives (n p charts)

(3) Control charts for percent defectives chart or 100 p-charts.

(4) Control charts for number of defects per unit or C-chart.

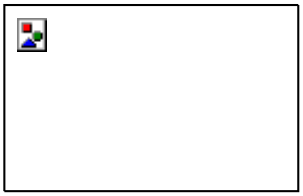
(1) CONTROL CHARTS FOR FRACTION DEFECTIVE (P-CHART):

Let samples of size n be taken randomly from the production process or output at different time intervals. If d is the number of defectives in a sample, then the fraction defective in the sample.

Or Actual number of defectives, 

If $\bar{p}$ is the proportion of defectives produced by the entire processing or the average fraction defective and it is given by

$\bar{p}$ The p-chart is based on binomial distribution. The binomial distribution has the standard deviation σ_p which is given by the relation.



Thus the control limits for the p-chart are:

Central Line CL = 

Upper control Limit UCL = 

Lower control Limit LCL = $\bar{P} - 3\sigma_p = \bar{P} - 3\sqrt{\frac{P(1-\bar{P})}{n}}$

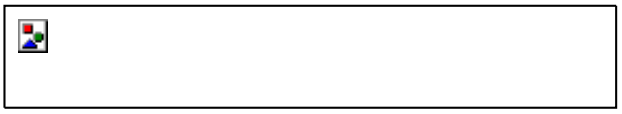
Since the number of defective products cannot be negative if LCL sometimes comes out to be negative, it is taken as zero, p-chart is used to plot and control fraction defectives when the sample size remains uniform or it varies.

(2) CONTROL CHARTS FOR NUMBER OF DEFECTIVES (np-CHART):

Using the same notations as in p-chart the standard deviation and control limits of np-chart are as follows:

Standard deviation 

Control Limits CL = 

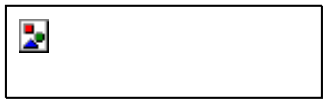
UCL = 

LCL = 

(3) CONTROL CHARTS FOR PERCENT DEFECTIVE (100 P-CHART):

Using the same notation as in p, np charts, the standard deviation and control limits are as follows:

Central Line, CL = 

UCL = 

LCL = $100 \times \bar{P} - 3\sigma_{100p}$

(4) CONTROL CHARTS FOR NUMBER OF DEFECTS PER UNIT (C-CHART):

This is another method of plotting attribute characteristics. In number of cases, it is more convenient to work with number of defects per unit rather than with fraction defective. The R-chart is used for the control of the number of defects observed per unit.

The difference between p-chart and the r-chart is that the former takes into account the number of items found defective in a given sample size (each defective item may have one or more defects in it) while the latter records the number of defects found in a given sample size.

Although the application of c-chart is somewhat limited, compared with p-chart, there are instances in industry where it is very useful e.g. in the control of number of defects in a bus body, an aircraft a T.V. set, a computer, welding defect in a truss etc.

The construction of the control chart is similar to that of the p-chart except that here the control limits are based on the Poisson distribution which has often been found fit to describe distribution of defects.

The standard deviation in this case is given by

Where  is the average number of defects?

The control limits for c-chart are:

CL = 

UCL = 

LCL = 

These control limits are for constant sample size i.e., for a single unit only. In case the sample consists of a numbers of unit's n, the average number of defects per unit

Control limits will be

CL = $\bar{U}$

UCL = $\bar{U} + 3\sqrt{\frac{U}{n}} = \bar{U} + 3\sqrt{\bar{c}}$

LCL = 

Whenever  so that LCL is negative, it is taken as being 0.

CONTROL CHARTS FOR ATTRIBUTES:

Control Limits for P-Chart

$$UCL_p = \bar{p} + 3\sqrt{\bar{p}(1-\bar{p})/n} = \bar{p} + 3\sigma_p$$

$$LCL_p = \bar{p} - 3\sqrt{\bar{p}(1-\bar{p})/n} = \bar{p} - 3\sigma_p$$

Where

p = Process percent defective of a sample

= (Number of defective Items in a sample size)

$\bar{p}$ = Process mean percent defective

n = Sample size

k = Number of samples

σ_p = Standard deviation of percent defectives

Control Limits for C-Chart

$$UCL_c = \bar{c} + 3\sqrt{\bar{c}}$$

$$LCL_c = \bar{c} - 3\sqrt{\bar{c}}$$

Where $\bar{c}$ is the mean number of non-conformities?

APPLICABILITY OF P-CHARTS:

(1) np or Number of defective chart is used where group size or sample size i.e. n is constant.

(2) p-chart of fraction defective chart and 100 p or percent defective charts can be used where sample size is variable or constant.

COMPARISON OF $\bar{X}$ -R-CHARTS AND P-CHARTS:

$\bar{x}$ – R-Charts:

(1) These are Control Charts for variables.

(2) Cost of data collection is more due to actual dimensional measurements.

(3) Sample sizes are small.

(4) The control limits are affected by sample size.

(5) For different measurable quality characteristics different charts are to be drawn.

(6) The method is much superior in diagnosing of causes of variability.

P-Charts:

(1) These are Control Charts for attributes.

(2) Data collection is comparatively cheaper.

(3) Larger size samples are to be taken.

(4) There is less effect of the sample size over control limits.

(5) Same P-chart may be applied to any number of quality characteristics on one item under inspection.

(6) The method is comparatively inferior regarding diagnosing the causes of trouble or rejections.

ADVANTAGES OF STATISTICAL QUALITY CONTROL:

Following are the important benefits derived from the technique of statistical qualify control:

(1) Lesser cost of inspection: Statistical quality control is based on sampling technique which involves lesser cost of inspection thereby cost of production is considerably reduced.

(2) Increase in profits: By minimising rejections, statistical quality control ensures the production of standard products which bring higher profits for the producer.

(3) Setting tolerance limits: Quality control charts clearly lay down the tolerances limits beyond which the product is to be rejected. The results shown by these charts are more authentic and correct.

(4) Develops quality consciousness: Statistical quality control is greatly helpful in developing the feeling of quality consciousness among the workers working in an organisation. This improves their functioning and reduces the number of defective operations undertaken by them.

(5) Enhances reputation of the concern: By adopting the techniques of statistical quality control, pre-determined quality of the product is achieved and consumers get desired quality products. This brings good name to the firm and increases its goodwill among the people.

(6) Improved relations between vendor and customers: It is greatly helpful in improving relations between supplier and the purchaser of material, by clearly fixing the tolerance limits with regard to quality of the goods supplied. This minimises the possibility of any dispute between both the parties.

Besides the above mentioned benefits, statistical quality control ensures smooth and unrestricted production by removing breakdown of machinery and work stoppages as it greatly helps in detection of the troubles soon, which are immediately corrected without delay.

Table 1: Constants for constructing control charts.

Observations in Subgroup, n	c4 for Limits based on Subgroup Sigma	d2 for Xbar Limits based on Subgroup Range	d3 for Range Limits
2	0.7979	1.128	0.853
3	0.8862	1.693	0.888
4	0.9213	2.059	0.88
5	0.94	2.326	0.864
6	0.9515	2.534	0.848
7	0.9594	2.704	0.833
8	0.965	2.847	0.82
9	0.9693	2.97	0.808
10	0.9727	3.078	0.797
11	0.9754	3.173	0.787
12	0.9776	3.258	0.778
13	0.9794	3.336	0.77
14	0.981	3.407	0.763
15	0.9823	3.472	0.756
16	0.9835	3.532	0.75
17	0.9845	3.588	0.744
18	0.9854	3.64	0.739
19	0.9862	3.689	0.734
20	0.9869	3.735	0.729
21	0.9876	3.778	0.724
22	0.9882	3.819	0.72
23	0.9887	3.858	0.716
24	0.9892	3.895	0.712
25	0.9896	3.931	0.708

Table 2: Used for alternate forms of calculations.

Observations in Subgroup, n	A2 for Xbar Limits based on Range	A3 for Xbar Limits based on Sigma	B3 for Sigma chart LCL	B4 for Sigma chart UCL	D3 for Range chart LCL	D4 for Range chart UCL
2	1.88	2.659	0	3.267	0	3.267
3	1.023	1.954	0	2.568	0	2.574
4	0.729	1.628	0	2.266	0	2.282
5	0.577	1.427	0	2.089	0	2.114
6	0.483	1.287	0.03	1.97	0	2.004
7	0.419	1.182	0.118	1.882	0.076	1.924
8	0.373	1.099	0.185	1.815	0.136	1.864
9	0.337	1.032	0.239	1.761	0.184	1.816
10	0.308	0.975	0.284	1.716	0.223	1.777
11	0.285	0.927	0.321	1.679	0.256	1.744
12	0.266	0.886	0.354	1.646	0.283	1.717
13	0.249	0.85	0.382	1.618	0.307	1.693
14	0.235	0.817	0.406	1.594	0.328	1.672
15	0.223	0.789	0.428	1.572	0.347	1.653
16	0.212	0.763	0.448	1.552	0.363	1.637
17	0.203	0.739	0.466	1.534	0.378	1.622
18	0.194	0.718	0.482	1.518	0.391	1.608
19	0.187	0.698	0.497	1.503	0.403	1.597
20	0.18	0.68	0.51	1.49	0.415	1.585
21	0.173	0.663	0.523	1.477	0.425	1.575
22	0.167	0.647	0.534	1.466	0.434	1.566
23	0.162	0.633	0.545	1.455	0.443	1.557
24	0.157	0.619	0.555	1.445	0.451	1.548
25	0.153	0.606	0.565	1.435	0.459	1.541

PROBLEMS ON CONTROL CHARTS FOR THE VARIABLE TYPE OF DATA (X BAR AND R CHARTS)

Example 1: A team collected the variables data recorded in the table below.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
X1	6	2	5	3	2	5	4	7	2	5	3	6	4	5	3	6
X2	5	7	6	6	8	4	6	4	3	5	1	4	3	4	4	2
X3	2	9	4	6	3	8	3	4	7	2	6	2	6	6	7	4
X4	7	3	2	7	5	4	6	5	1	6	5	2	6	2	3	4

Use these data to answer the following questions and plot a Control Chart:

1. What type of Control Chart would you use with these data?
2. Why?
3. What are the values of X-Bar for each subgroup?
4. What are the values of the ranges (R) for each subgroup?
5. What is the grand mean for the X-Bar data?
6. What is the average of the range (R) values?
7. Compute the values for the upper and lower control limits for both the upper and lower plotting areas.
8. Plot the Control Chart.
9. Are there any signals of special cause variation? If so, what rule did you apply to identify the signal?

Solution:

1. X-Bar and R.
2. There is more than one measurement within each subgroup.
3. For values of X-Bar for each subgroup Refer to table 1.
4. For values of the ranges for each subgroup Refer to table 1.

Table 1. Shows X-Bar and ranges for each subgroup

	X1	X2	X3	X4	X Bar	R
1	6	5	2	7	5	5
2	2	7	9	3	5.25	7
3	5	6	4	2	4.25	4
4	3	6	6	7	5.5	4
5	2	8	3	5	4.5	6
6	5	4	8	4	5.25	4
7	4	6	3	6	4.75	3
8	7	4	4	5	5	3
9	2	3	7	1	3.25	6
10	5	5	2	6	4.5	4
11	3	1	6	5	3.75	5
12	6	4	2	2	3.5	4
13	4	3	6	6	4.75	3
14	5	4	6	2	4.25	4
15	3	4	7	3	4.25	4

16	6	2	4	4	4	4

5. Grand Mean of X,

Control Limit $\bar{\bar{x}} = \dfrac{\overline{x_1} + \overline{x_2} + \overline{x_3} + \cdots \ldots \ldots \overline{x_m}}{m}$

$$\bar{\bar{x}} = \frac{5 + 5.25 + 4.25 + 5.5 + 4.5 + 5.25 + 4.75 + 5 + 3.25 + 4.5 + 3.75 + 3.5 + 4.75 + 4.25 + 4.25 + 4}{16}$$

$$\bar{\bar{x}} = \frac{71.75}{16} = 4.484 \ (Center\ Line\ of\ X\ bar\ chart)$$

6. Average of the range values $\bar{R}$

$$\bar{R} = \frac{5+7+4+4+6+4+3+3+6+4+5+4+3+4+4+4}{16}$$

$$\bar{R} = \frac{70}{16} = 4.375 \ (Center\ Line\ for\ R\ chart)$$

7. $\bar{x}$ Chart: - U.C.L. = $\bar{\bar{x}} + A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} + \frac{3\bar{R}}{d_2\sqrt{n}}$ if d_2 is given

L.C.L. = $\bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} - \frac{3\bar{R}}{d_2\sqrt{n}}$ if d_3 is given

R Chart: - U.C.L. = $D_4\bar{R}$ if D_4 is given

or $= \bar{R}[\frac{1+3d_3}{d_2}]$ if d_2, & d_3 is given

L.C.L. = $D_3\bar{R}$ if D_3 is given

or $= \bar{R}[\frac{1-3d_3}{d_2}]$ if d_2, & d_3 is given

Now: $\bar{x}$ Chart: U.C.L. = $\bar{\bar{x}} + A_2\bar{R}$

$$= 4.484 + A_2 4.375 \ (if\ A_2 = 0.729\ for\ sample\ size\ 4)$$

$$= 4.484 + (0.729 \times 4.375) = 7.67$$

Lower Control Limit, L.C.L. = $\bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

$$= 4.484 - A_2 4.375 (if\ A_2 = 0.729\ for\ sample\ size\ 4)$$

$$= 4.484 - (0.729 \times 4.375) = 1.29$$

$\bar{R}$ Chart:

Upper Control Limit, U.C.L. = $D_4\bar{R}$ if D_4 is given

$$= D_4 \times 4.375 \ (if\ D_4 = 2.282\ for\ sample\ size\ 4)$$

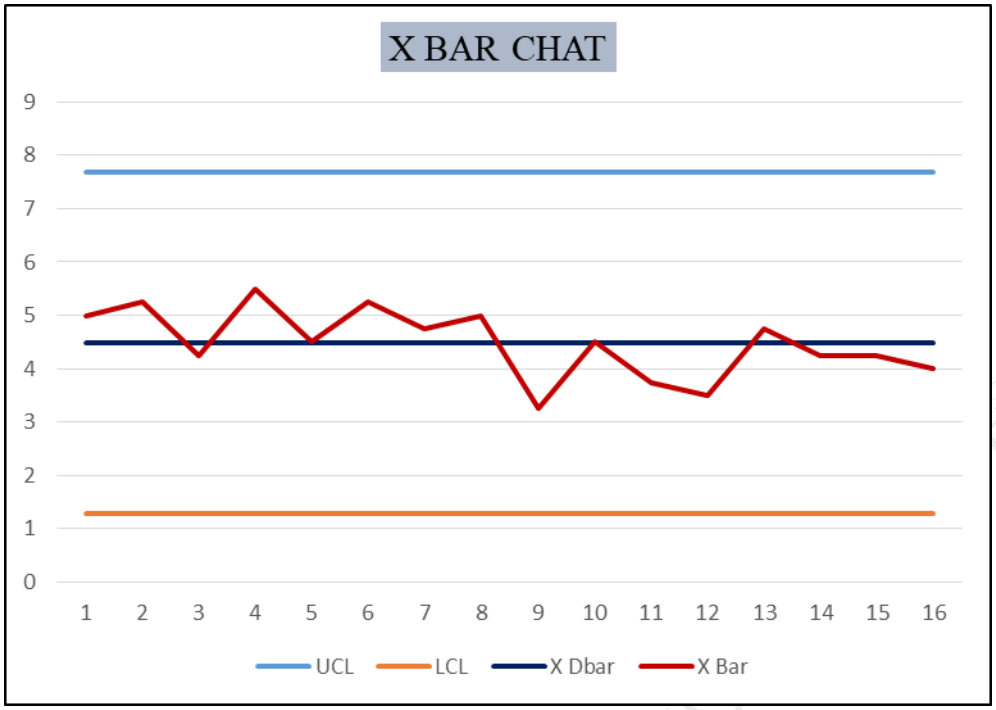
$$= 2.282 \times 4.375 = 9.98 \approx 10$$

Lower Control Limit, L.C.L. = $D_3\bar{R}$ if D_4 is given

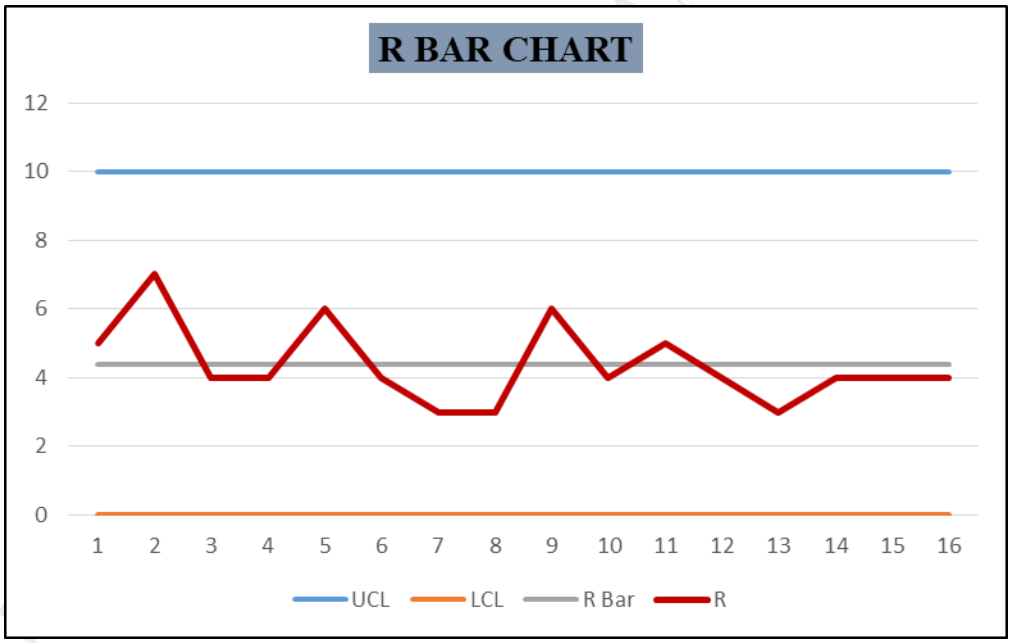
$$= D_3 \times 4.375 \ (if\ D_3 = 0\ for\ sample\ size\ 4)$$

$= 0 \times 4.375 = 0$

8. Plotting the Control Chart using – X bar – chart



Plotting the Control Chart using – R – Chart



9. There is no out of control signals and all the subgroups are accepted.

Example 2: A team collected the variables data recorded in the table below.

	1	2	3	4	5	6	7	8	9
X1	15.3	14.4	15.3	15.0	15.3	14.9	15.6	14.0	14.0
X2	14.9	15.5	15.1	14.8	16.4	15.3	16.4	15.8	15.2
X3	15.0	14.8	15.3	16.0	17.2	14.9	15.3	16.4	13.6
X4	15.2	15.6	18.5	15.6	15.5	16.5	15.3	16.4	15.0
X5	16.4	14.9	14.9	15.4	15.5	15.1	15.0	15.3	15.0

Use these data to answer the following questions and plot a Control Chart:

1. What type of Control Chart would you use with these data?

2. Why?
3. What are the values of X-Bar for each subgroup?
4. What are the values of the ranges for each subgroup?
5. What is the grand mean for the X-Bar data?
6. What is the average of the range values?
7. Compute the values for the upper and lower control limits for both the upper and lower plotting areas.
8. Plot the Control Chart.
9. Are there any signals of special cause variation? If so, what rule did you apply to identify the signal?

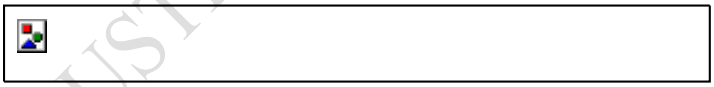
Solution:

1. X-Bar and R.
2. There is more than one measurement within each subgroup.
3. For values of X-Bar for each subgroup Refer to table 1.
4. For values of the ranges for each subgroup Refer to table 1.

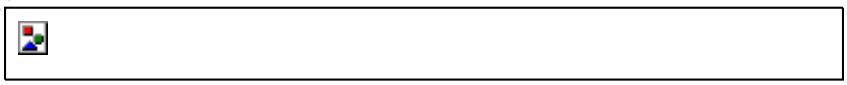
Table 1. Shows X-Bar and ranges for each subgroup

	X1	X2	X3	X4	X5	X Bar	R
1	15.3	14.9	15	15.2	16.4	15.36	1.5
2	14.4	15.5	14.8	15.6	14.9	15.04	1.2
3	15.3	15.1	15.3	18.5	14.9	15.82	3.6
4	15	14.8	16	15.6	15.4	15.36	1.2
5	15.3	16.4	17.2	15.5	15.5	15.98	1.9
6	14.9	15.3	14.9	16.5	15.1	15.34	1.6
7	15.6	16.4	15.3	15.3	15	15.52	1.4
8	14	15.8	16.4	16.4	15.3	15.58	2.4
9	14	15.2	13.6	15	15	14.56	1.6

5. Grand Mean of X,



6. Average of the range values



$$\bar{R} = \frac{16.4}{9} = 1.822 \ (Center\ Line\ for\ R\ chart)$$

7. $\bar{x}$ Chart: - U.C.L. = $\bar{\bar{x}} + A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} + \frac{3\bar{R}}{d_2\sqrt{n}}$ if d_2 is given

L.C.L. = $\bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} - \frac{3\bar{R}}{d_3\sqrt{n}}$ if d_3 is given

R Chart: - U.C.L. = $D_4\bar{R}$ if D_4 is given

or $= \bar{R}[\frac{1+3d_3}{d_2}]$ if d_2, & d_3 is given

L.C.L. = $D_3\bar{R}$ if D_3 is given

or $= \bar{R}[\frac{1-3d_3}{d_2}]$ if d_2, & d_3 is given

Now: $\bar{x}$ Chart: U.C.L. = $\bar{\bar{x}} + A_2\bar{R}$

$$= 15.217 + A_2 1.822 \ (if\ A_2 = 0.577\ for\ sample\ size\ 5)$$
$$= 15.217 + (0.577 \times 1.822) = 16.95$$

Lower Control Limit, L.C.L. = $\bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

$$= 15.217 - A_2 1.822 (if\ A_2 = 0.577\ for\ sample\ size\ 5)$$
$$= 15.217 - (0.577 \times 1.822) = 13.49$$

$\bar{R}$ Chart:

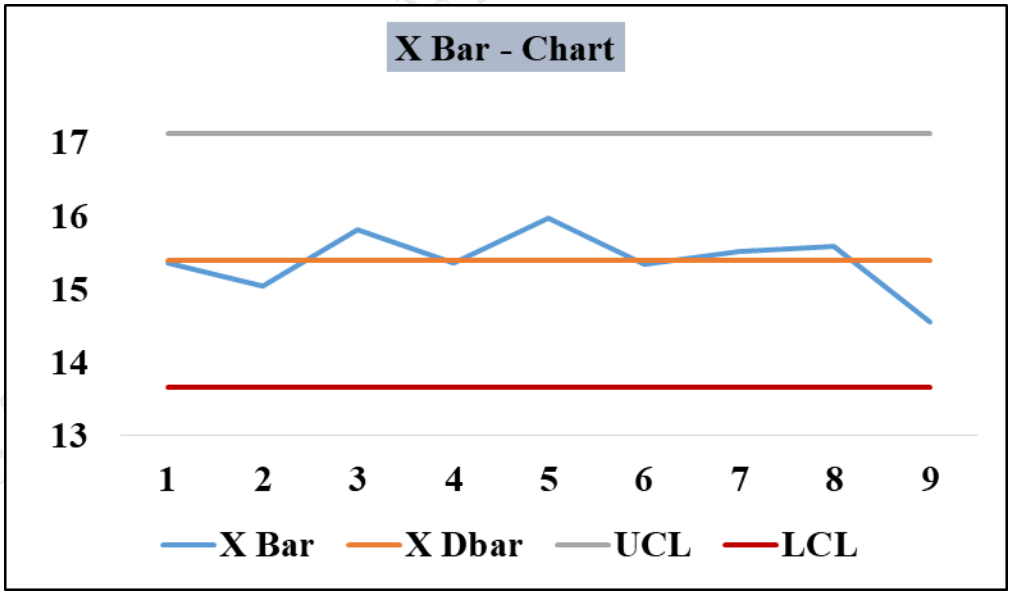
Upper Control Limit, U.C.L. = $D_4\bar{R}$ if D_4 is given

$$= D_4 \times 1.822 \ (if\ D_4 = 2.114\ for\ sample\ size\ 5)$$
$$= 2.282 \times 1.822 = 3.85 \approx 4$$

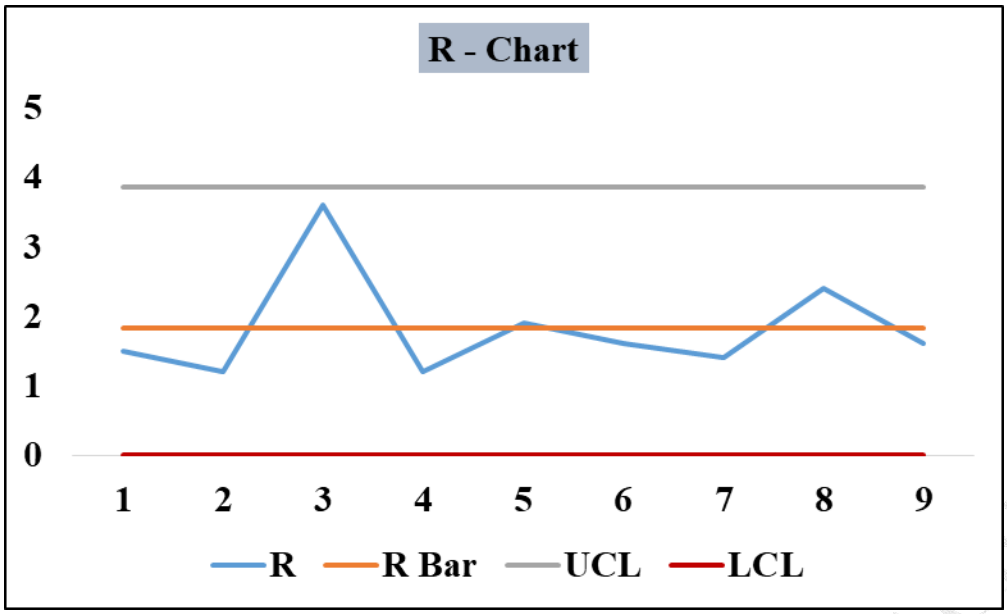
Lower Control Limit, L.C.L. = $D_3\bar{R}$ if D_4 is given

$$= D_3 \times 1.822 \ (if\ D_3 = 0\ for\ sample\ size\ 4)$$
$$= 0 \times 1.822 = 0.00$$

8. Plotting the Control Chart using – X bar – Chart



Plotting the Control Chart using – R – Chart



9. There is no out of control signals from X Bar and R Charts and all the subgroups are accepted.

Example 3: Mean values and ranges of data from 20 samples (sample size = 4) are shown in the table below:

S. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Mean of Sample	10	15	12	11	9	11	11	9	10	11	12	13	12	12	11	15	12	15	11	10
Range	4	4	5	4	5	6	4	4	4	6	5	4	4	3	3	4	4	3	3	4

Solution:

Given Data:

No. of Sample size, n = 4

To Find:

Range $\bar{R}$

Control Limit $\bar{\bar{X}}$,

Upper Control Limit (UCL)

Lower Control Limit (LCL)

We Know:

Control Limit $\bar{\bar{x}} = \frac{\overline{x_1} + \overline{x_2} + \overline{x_3} + \cdots \ldots\ldots \overline{x_m}}{m}$

$\bar{x}$ Chart: - U.C.L. = $\bar{\bar{x}} + A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} + \frac{3\bar{R}}{d_2\sqrt{n}}$ if d_2 is given

L.C.L. = $\bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

or $= \bar{\bar{x}} - \frac{3\bar{R}}{d_2\sqrt{n}}$ if d_3 is given

R Chart: - U.C.L. = $D_4\bar{R}$ if D_4 is given

or $= \bar{R}\left[\frac{1+3d_3}{d_2}\right]$ if d_2, & d_3 is given

L.C.L. $= D_3\bar{R}$ if D_3 is given

or $= \bar{R}\left[\frac{1-3d_3}{d_2}\right]$ if d_2, & d_3 is given

Now:

Control Limit $\bar{\bar{x}} = \frac{\overline{x_1} + \overline{x_2} + \overline{x_3} + \cdots \ldots\ldots \overline{x_m}}{m}$

$$\bar{\bar{x}} = \frac{10+15+12+11+9+11+11+9+10+11+12+13+12+12+11+15+12+15+11+10}{20}$$

$$\bar{\bar{x}} = \frac{232}{20} = 11.6 \ (Center\ Line\ of\ X\ bar\ chart)$$

Range,

$$\bar{R} = \frac{4+4+5+4+5+6+4+4+4+6+5+4+4+3+3+4+4+3+3+4}{20}$$

$$\bar{R} = \frac{83}{20} = 4.15 \ (Center\ Line\ for\ R\ chart)$$

$\bar{x}$ Chart:

Upper Control Limit, U.C.L. $= \bar{\bar{x}} + A_2\bar{R}$ if A_2 is given

$$= 11.6 + A_2 4.15 \ (if\ A_2 = 0.729\ for\ sample\ size\ 4)$$
$$= 11.6 + (0.729 \times 4.15) = 14.63$$

Lower Control Limit, L.C.L. $= \bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

$$= 11.6 - A_2 4.15 \ (if\ A_2 = 0.729\ for\ sample\ size\ 4)$$
$$= 11.6 - (0.729 \times 4.15) = 8.57$$

$\bar{R}$ Chart:

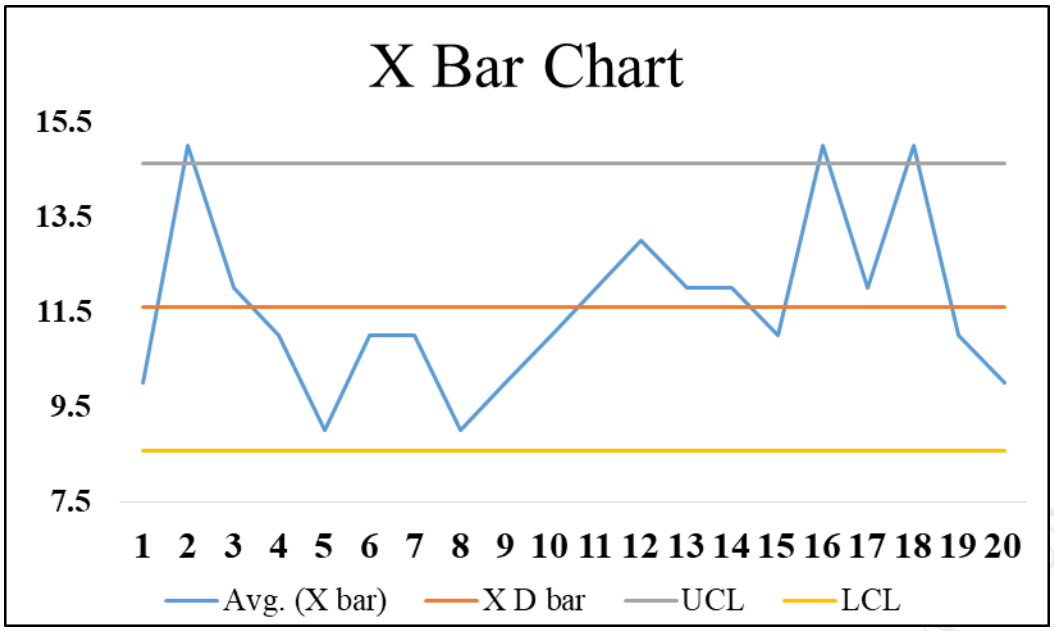
Upper Control Limit, U.C.L. $= D_4\bar{R}$ if D_4 is given

$$= D_4 \times 4.15 \ (if\ D_4 = 2.282\ for\ sample\ size\ 4)$$
$$= 2.282 \times 4.15 = 9.47 \approx 9.5$$

Lower Control Limit, L.C.L. $= D_3\bar{R}$ if D_3 is given

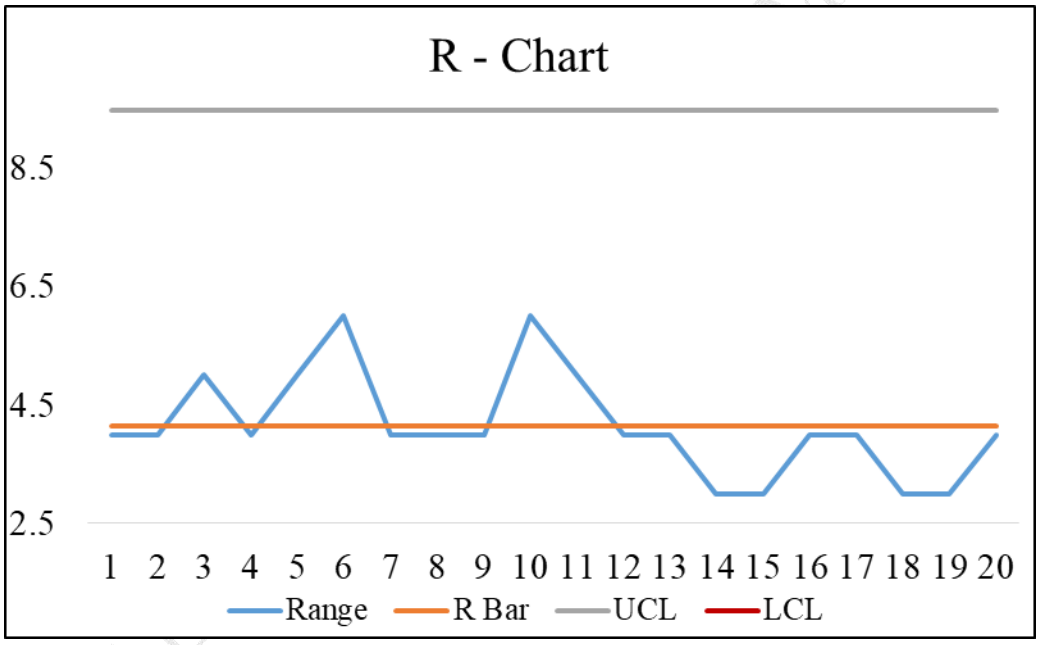
$$= D_3 \times 4.15 \ (if\ D_3 = 0\ for\ sample\ size\ 4)$$
$$= 0 \times 4.15 = 0$$

Know we have to draw Control chart using – X bar – chart



Comment: Sample data at S.N 2, 16, and 18 are slightly above the UCL. Hence, the process is not under control.

Know we have to draw Control chart using – R bar – chart



Comment: From the above control chart all the points are within control limits. Hence the quality is considered to be under control.

In order to assure for the quality we have to delete the subgroups 2, 16 and 18 and again we will calculate greater mean and range values.

Now,

Control Limit $\bar{\bar{x}} = \dfrac{\overline{x_1} + \overline{x_2} + \overline{x_3} + \cdots \ldots \ldots \overline{x_m}}{m}$

$$\bar{\bar{x}} = \frac{10 + 12 + 11 + 9 + 11 + 11 + 9 + 10 + 11 + 12 + 13 + 12 + 12 + 11 + 12 + 11 + 10}{17}$$

$$\bar{\bar{x}} = \frac{187}{17} = 11 \ (Center\ Line\ of\ X\ bar\ chart)$$

Range,

$$\bar{R} = \frac{4 + 5 + 4 + 5 + 6 + 4 + 4 + 4 + 6 + 5 + 4 + 4 + 3 + 3 + 4 + 3 + 4}{17}$$

$\bar{R} = \frac{72}{17} = 4.23\ (Center\ Line\ for\ R\ chart)$

$\bar{x}$ Chart:

Upper Control Limit, U.C.L. = $\bar{\bar{x}} + A_2\bar{R}$ if A_2 is given

$$= 11 + A_2 4.23\ (if\ A_2 = 0.729\ for\ sample\ size\ 4)$$

$$= 11 + (0.729 \times 4.23) = 14.083$$

Lower Control Limit, L.C.L. = $\bar{\bar{x}} - A_2\bar{R}$ if A_2 is given

$$= 11 - A_2 4.23\ (if\ A_2 = 0.729\ for\ sample\ size\ 4)$$

$$= 11 - (0.729 \times 4.23) = 7.91$$

$\bar{R}$ Chart:

Upper Control Limit, U.C.L. = $D_4\bar{R}$ if D_4 is given

$$= D_4 \times 4.23\ (if\ D_4 = 2.282\ for\ sample\ size\ 4)$$

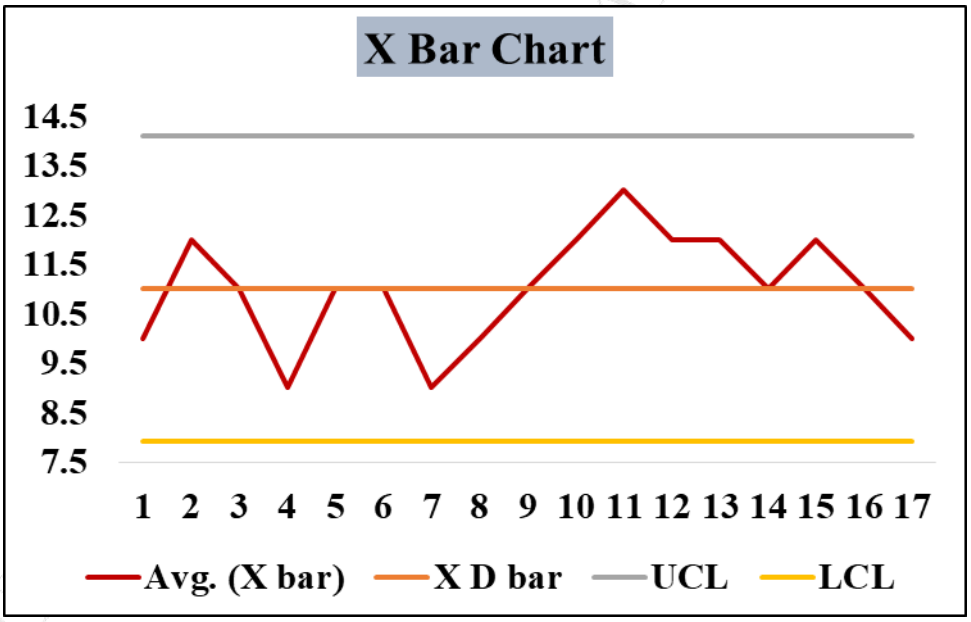
$$= 2.282 \times 4.23 = 9.65$$

Lower Control Limit, L.C.L. = $D_3\bar{R}$ if D_3 is given

$$= D_3 \times 4.23\ (if\ D_3 = 0\ for\ sample\ size\ 4)$$

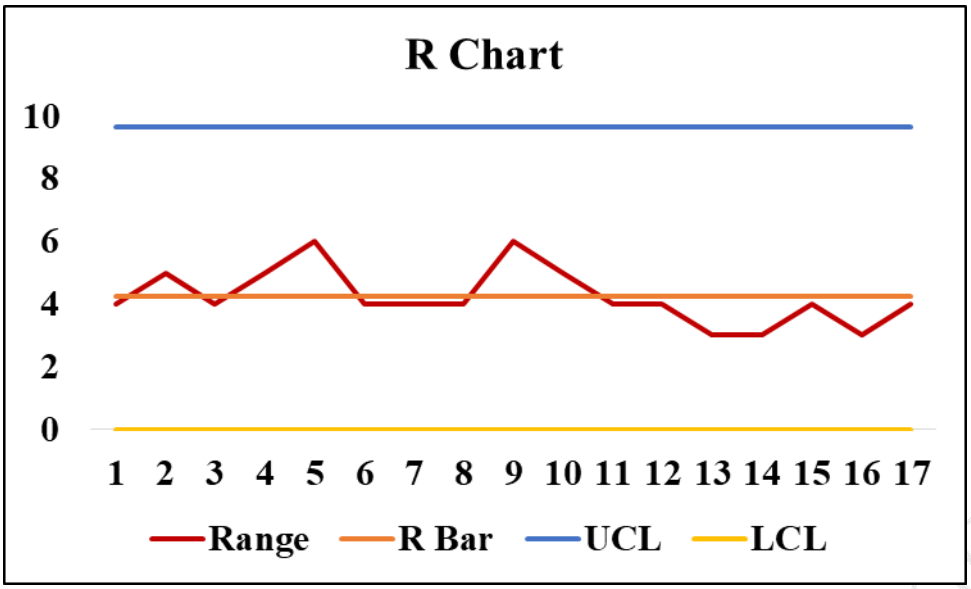
$$= 0 \times 4.23 = 0$$

Know we have to draw Control chart using – X bar – chart



Comment: From the above control chart all the points are within control limits. Hence the quality is considered to be under control.

Know we have to draw Control chart using S – Chart



Comment: From the above control chart all the points are within control limits. Hence the quality is considered to be under control.

PROBLEMS ON CONTROL CHARTS FOR THE VARIABLE TYPE OF DATA (X BAR AND S CHARTS)

Example 1: The following is a small example of a quantitative process, calculate the subgroup means and standard deviations, then plot the means and calculate the upper and lower control limits for the X bar and S chart.

	M1	M2	M3	M4
S1	2.3	2.2	2.4	2.3
S2	2.1	2.2	2.3	2.4
S3	2	2.1	2.2	2.1
S4	2	2.2	2.1	2.3
S5	2.5	2.1	2.4	2.3

Solution:

Given data:

No. of Groups/Samples, k=5

No. of Subgroups/Observations, n=4

To find:

1. Grand Mean $\bar{\bar{x}}$,
2. Values of Sigma, S,
3. Average of Sigma values $\bar{S}$,

We know that

$$\text{Grand Mean/Control Limit } \bar{\bar{x}} = \frac{\overline{x_1} + \overline{x_2} + \overline{x_3} + \cdots \ldots \ldots \overline{x_n}}{n}$$

$$\text{Standard Deviation, } S = \sqrt{\frac{\Sigma_1^n (X_i - \bar{X})^2}{n-1}}$$

$$\text{Average of Sigma values } \bar{S} = \frac{\Sigma_1^k S_i}{k}$$

For X-Bar Chart

$$\text{Control Limit, } \bar{\bar{x}} = \frac{\overline{x_1}+\overline{x_2}+\overline{x_3}+\cdots\ldots\ldots\overline{x_k}}{k}$$

$UCL = \bar{\bar{X}} + A_3\bar{S}$

$LCL = \bar{\bar{X}} - A_3\bar{S}$

For Sigma (S) Chart

$$\text{Control Limit, } \bar{S} = \frac{\Sigma_1^k S_i}{k}$$

$$UCL = B_4\bar{S}$$

$LCL = B_3\bar{S}$

Know:

For X-Bar Chart

Control Limit, $\bar{\bar{x}} = \frac{\overline{x_1}+\overline{x_2}+\overline{x_3}+\cdots\ldots\ldots\overline{x_k}}{k}$

$$\bar{\bar{x}} = \frac{2.30 + 2.25 + 2.10 + 2.15 + 2.33}{5}$$

$$= \frac{11.13}{5} = 2.225$$

$$\bar{\bar{x}} = 2.225$$

$$\text{Standard Deviation, } S_i = \sqrt{\frac{\Sigma_1^n (X_i - \bar{X})^2}{n-1}}$$

1. 
2. 
3. 
4. 
5. 

$$\bar{S} = \frac{\Sigma_1^k S_i}{k} = \frac{S_1+S_2+S_3+\cdots S_i}{k}$$

$$\bar{S} = \frac{0.0816 - 0.1291 + 0.0816 + 0.1291 + 0.01708}{5}$$

$$\bar{S} = \frac{0.5923}{5}$$

$$\bar{S} = 0.1185$$

$UCL = \bar{\bar{X}} + A_3\bar{S}$

$UCL = 2.225 + A_3 0.1185\ (A_3 = 1.628\ for\ sub\ group\ 4)$

$UCL = 2.225 + (1.628 \times 0.1185)$

$$\boldsymbol{UCL = 2.4179}$$

$LCL = \bar{\bar{X}} - A_3\bar{S}$

$LCL = 2.225 - A_3 0.1185$ $(A_3 = 1.628\ for\ sub\ group\ 4)$

$LCL = 2.225 - (1.628 \times 0.1185)$

$$\boldsymbol{LCL = 2.0320}$$

$LCL = \bar{\bar{X}} - A_3\bar{S}$

For Sigma (S) Chart

Control Limit, $\bar{S} = \frac{\Sigma_1^k S_i}{k}$

$$\boldsymbol{\bar{S} = 0.1185}$$

$UCL = B_4\bar{S}$

$LCL = B_3\bar{S}$

$\bar{S}$ Chart:

Upper Control Limit, U.C.L. $= B_4\bar{S}$

$= B_4 \times 0.1185$ $(if\ B_4 = 2.266\ for\ sample\ size\ 4)$

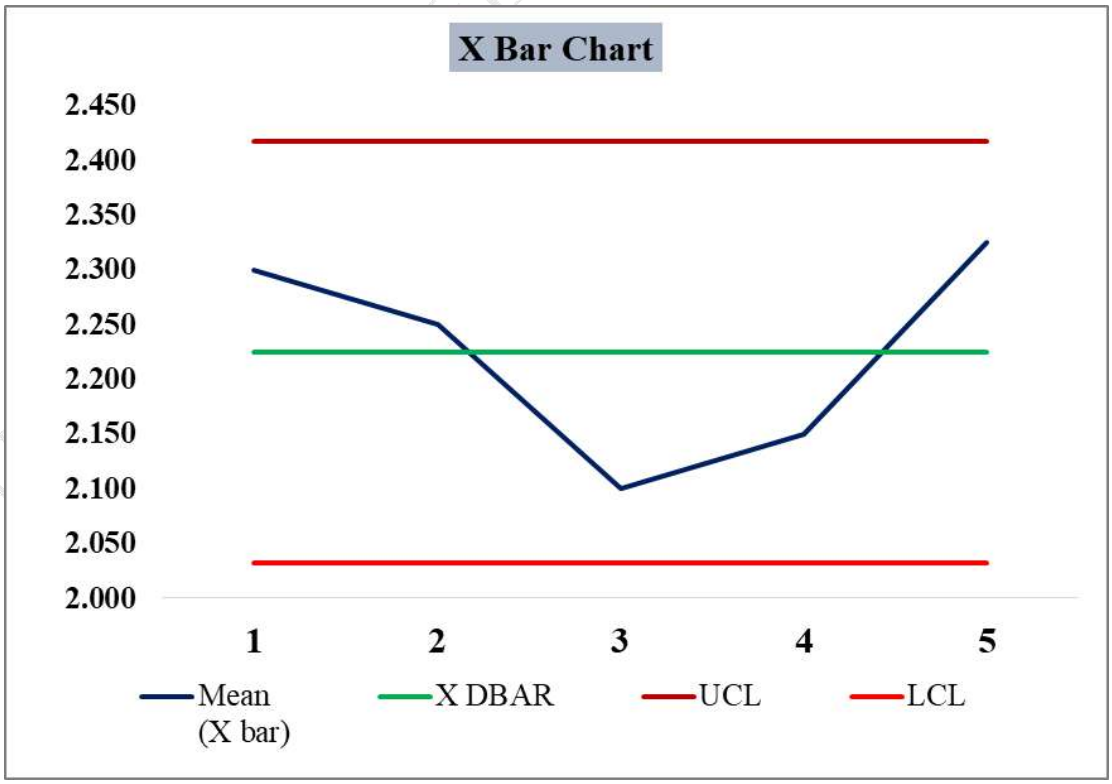
$= 2.266 \times 0.1185 = 0.268$

Lower Control Limit, L.C.L. $= B_3\bar{S}$

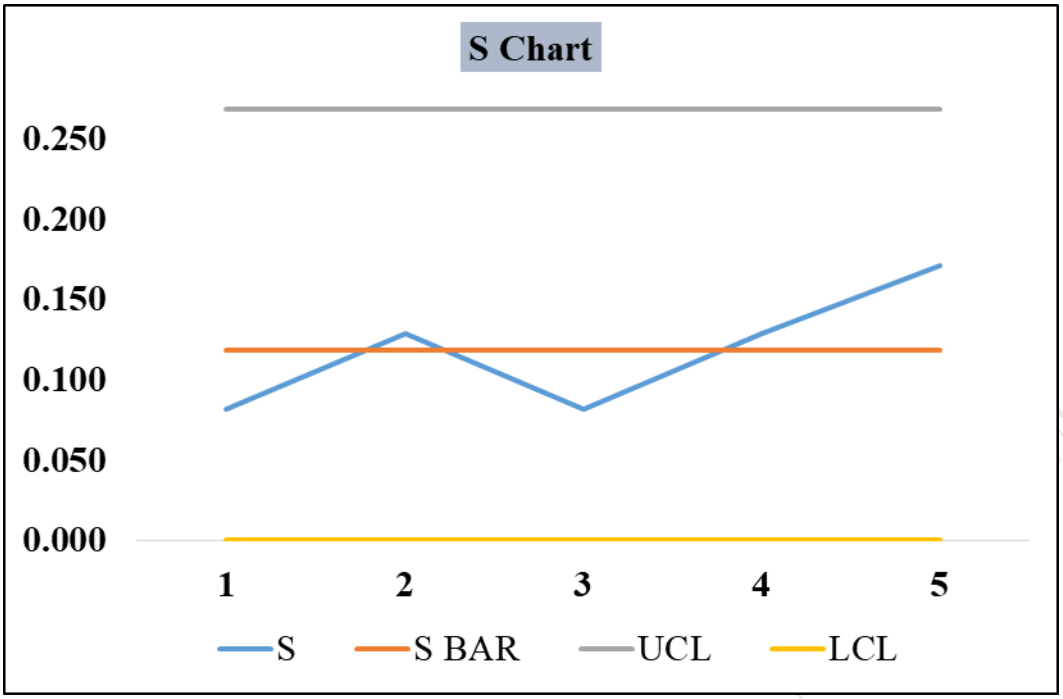
$= B_3 \times 0.1185$ $(if\ B_3 = 0\ for\ sample\ size\ 4)$

$= 0 \times 0.1185 = 0.00$

Plotting the Control Chart using X bar – Chart



Plotting the Control Chart using S – Chart



From the above two control charts we see that there is no special control signals. Therefore the samples are accepted.

Example 2: Given the following data for subgroups sizes of 8, construct the X Bar and S chart

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12
X-Bar	540	534	545	561	576	523	571	547	584	552	541	545
S	26	23	24	27	25	50	29	29	23	24	28	25

Sample No.	13	14	15	16	17	18	19	20	21	22	23	24	25
X-Bar	546	551	522	579	549	508	569	574	563	561	548	556	553
S	26	24	29	26	28	23	22	28	33	23	25	27	23

(Note: For sub-group size of 8 we have A_3 =1.099, B_3 = 0.185 & B_4 = 1.815**)**

Solution:

Given Data:

1. No. of samples, K=25
2. No. of Observation's/Sub-Groups/Sample Size, n=8

To Find:

1. Grand Mean $\bar{\bar{x}}$,
2. Average of Sigma values $\bar{S}$,

We know that

$$\text{Grand Mean/Control Limit } \bar{\bar{x}} = \frac{\overline{x_1} + \overline{x_2} + \overline{x_3} + \cdots \ldots \ldots \overline{x_n}}{n}$$

$$\text{Standard Deviation, } S = \sqrt{\frac{\Sigma_1^n (X_i - \bar{X})^2}{n-1}}$$

Average of Sigma values $\bar{S} = \frac{\Sigma_1^k S_i}{k}$

For X-Bar Chart

Control Limit, $\bar{\bar{x}} = \frac{\bar{x_1}+\bar{x_2}+\bar{x_3}+\cdots\ldots\ldots\bar{x_k}}{k}$

$UCL = \bar{\bar{X}} + A_3\bar{S}$

$LCL = \bar{\bar{X}} - A_3\bar{S}$

For Sigma (S) Chart

Control Limit, $\bar{S} = \frac{\Sigma_1^k S_i}{k}$

$UCL = B_4\bar{S}$

$LCL = B_3\bar{S}$

Know:

For X-Bar Chart

Control Limit, $\bar{\bar{x}} = \frac{\bar{x_1}+\bar{x_2}+\bar{x_3}+\cdots\ldots\ldots\bar{x_k}}{k}$

$\bar{\bar{x}} = \frac{540+534+545+561+576+523+571+547+584+552+541+545+546+551+522+579+549+508+569+574+563+561+548+556+553}{25}$

$= \frac{13798}{25} = 551.92$

$$\bar{\bar{x}} = 551.92$$

$$\bar{S} = \frac{\Sigma_1^k S_i}{k} = \frac{S_1 + S_2 + S_3 + \cdots S_{25}}{k}$$

$\bar{S} = \frac{26+23+24+27+25+50+29+29+23+24+28+25+26+24+29+26+28+23+22+28+33+23+25+27+23}{25}$

$\bar{S} = \frac{670}{25}$

$$\bar{S} = 26.80$$

$UCL = \bar{\bar{X}} + A_3\bar{S}$

$UCL = 551.92 + (A_3 \times 26.80)\ (A_3 = 1.099 for\ sub\ group\ 8)$

$UCL = 551.92 + (1.099 \times 26.80)$

$$UCL = 581.313$$

$LCL = \bar{\bar{X}} - A_3\bar{S}$

$LCL = 551.92 - (A_3 \times 26.80)\ (A_3 = 1.099\ for\ sub\ group\ 8)$

$LCL = 551.92 - (1.099 \times 26.80)$

$$LCL = 522.247$$

For Sigma (S) Chart

Control Limit, $\bar{S} = \frac{\Sigma_1^k S_i}{k}$

$$\bar{S} = 26.80$$

$$UCL = B_4\bar{S}$$

$LCL = B_3\bar{S}$

$\bar{S}$ Chart:

Upper Control Limit, U.C.L. $= B_4\bar{S}$

$$= B_4 26.80 \ (if\ B_4 = 1.815\ for\ sample\ size\ 8)$$

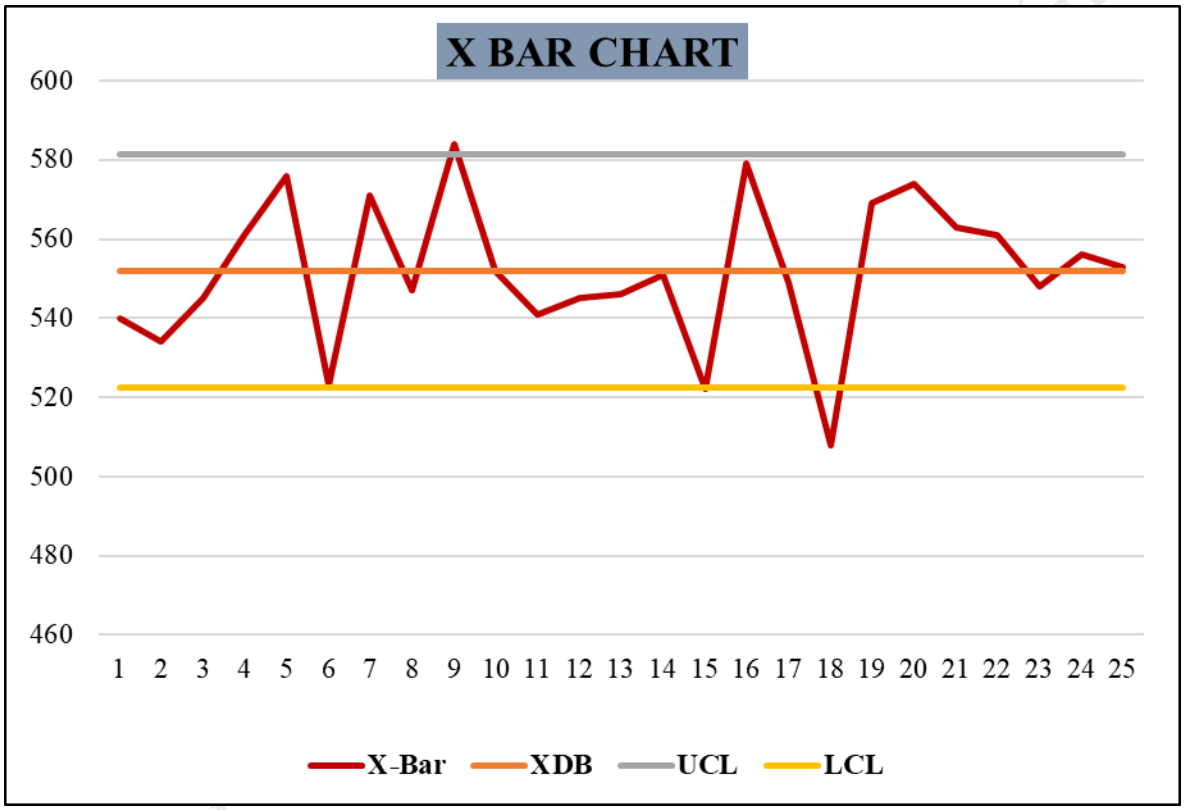
$$= 1.815 \times 26.80 = \mathbf{48.642}$$

Lower Control Limit, L.C.L. $= B_3\bar{S}$

$$= B_3 \times 26.80 \ (if\ B_3 = 0.185\ for\ sample\ size\ 8)$$

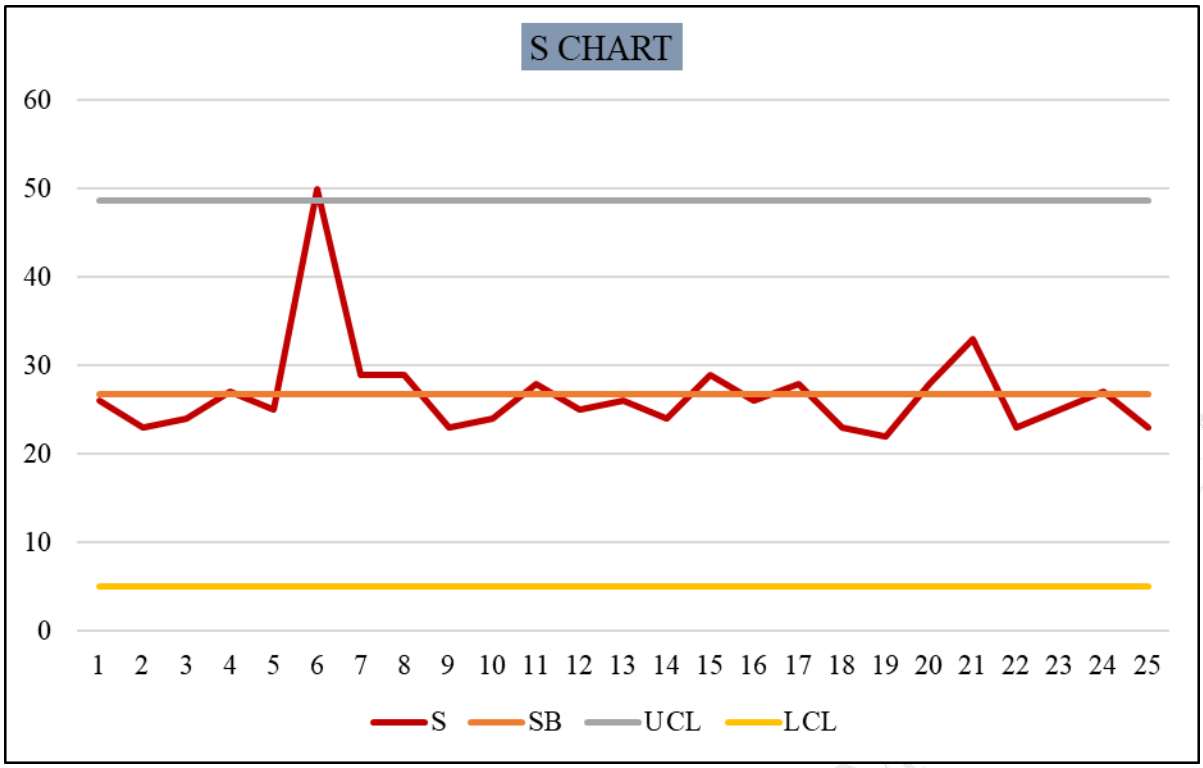
$$= 0.185 \times 26.80 = \mathbf{4.958}$$

Plotting the Control Chart using X bar – Chart



From the X Bar Chart we observed that sub groups 9 and 18 are out of control. So sub groups 9 and 18 are deleted and check for quality again.

Plotting the Control Chart using S – Chart



From the S chart we observed that sub group 6 has the special signal control i.e., out of control signal, in-order to accept the quality check we need to delete the sub group 6 and see that there is no special control signals.

Know the subgroups 6, 9 and 18 are eliminated and further the quality check will be done.

Know,

For X-Bar Chart

Control Limit, $\bar{\bar{x}} = \frac{\bar{x}_1+\bar{x}_2+\bar{x}_3+\cdots\ldots\ldots\bar{x}_k}{k}$

$$\bar{\bar{x}} = \frac{540 + 554 + 545 + 561 + 576 + 571 + 547 + 552 + 541 + 545 + 546 + 551 + 522 + 579 + 549 + 569 + 574 + +565 + 561 + 548 + 556 + 555}{22}$$

$$= \frac{12183}{22} = 553.77$$

$$\bar{\bar{x}} = 553.773$$

$$\bar{S} = \frac{\Sigma_1^k S_i}{k} = \frac{S_1 + S_2 + S_3 + \cdots S_{25}}{k}$$

$$\bar{S} = \frac{26+23+24+27+25+29+29+24+28+25+26+24+29+26+28+22+28+33+23+25+27+23}{22}$$

$$\bar{S} = \frac{574}{22} = 26.09$$

$$\bar{\bar{S}} = 26.091$$

$$UCL = \bar{\bar{X}} + A_3\bar{S}$$

$$UCL = 553.77 + (A_3 \times 26.09)\ (A_3 = 1.099 for\ sub\ group\ 8)$$

$$UCL = 553.77 + (1.099 \times 26.09)$$

$$\boldsymbol{UCL = 582.45}$$

$$LCL = \bar{\bar{X}} - A_3\bar{S}$$

$$LCL = 553.77 - (A_3 \times 26.09)\ (A_3 = 1.099\ for\ sub\ group\ 8)$$

$LCL = 553.77 - (1.099 \times 26.09)$

$$\boldsymbol{LCL = 525.10}$$

For Sigma (S) Chart

$$\text{Control Limit, } \bar{S} = \frac{\Sigma_1^k S_i}{k}$$

$$\boldsymbol{\bar{S} = 26.09}$$

$$UCL = B_4\bar{S}$$

$LCL = B_3\bar{S}$

$\bar{S}$ Chart:

Upper Control Limit, U.C.L. $= B_4\bar{S}$

$= B_4 26.09 \ (if \ B_4 = 1.815 \ for \ sample \ size \ 8)$

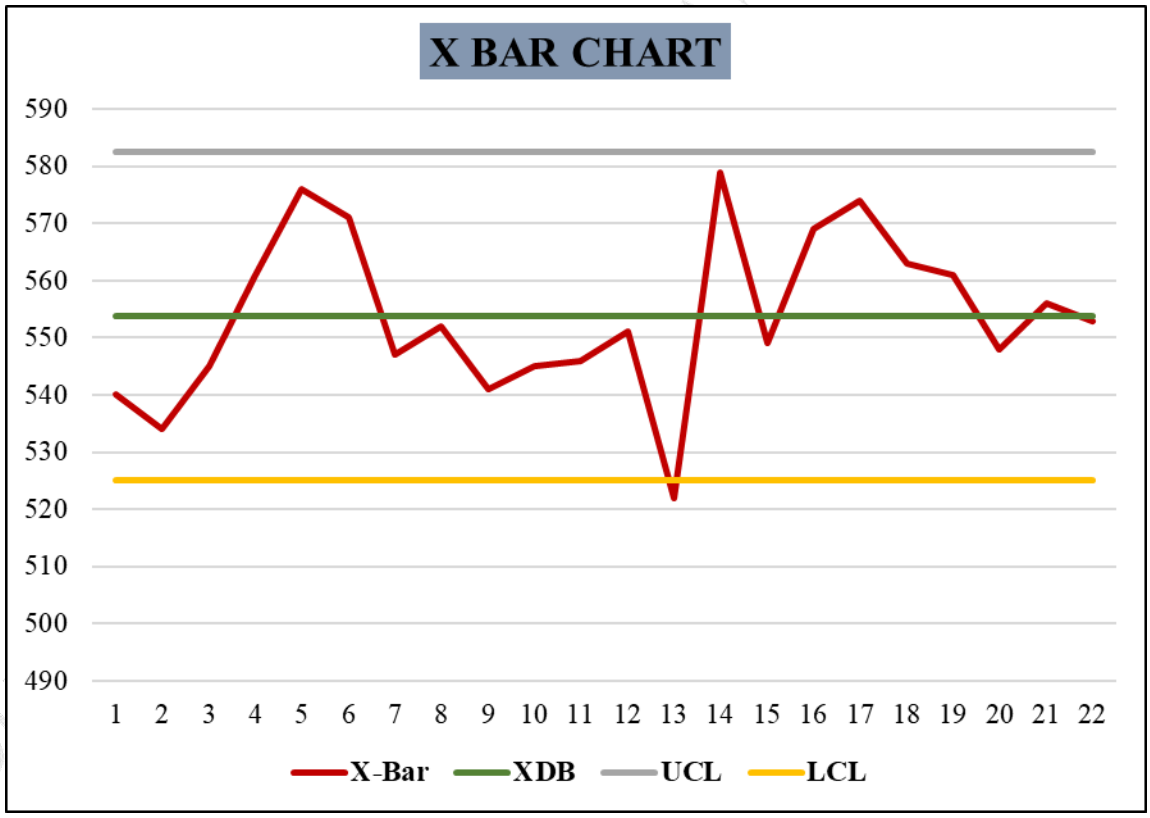
$= 1.815 \times 26.09 = 47.36$

Lower Control Limit, L.C.L. $= B_3\bar{S}$

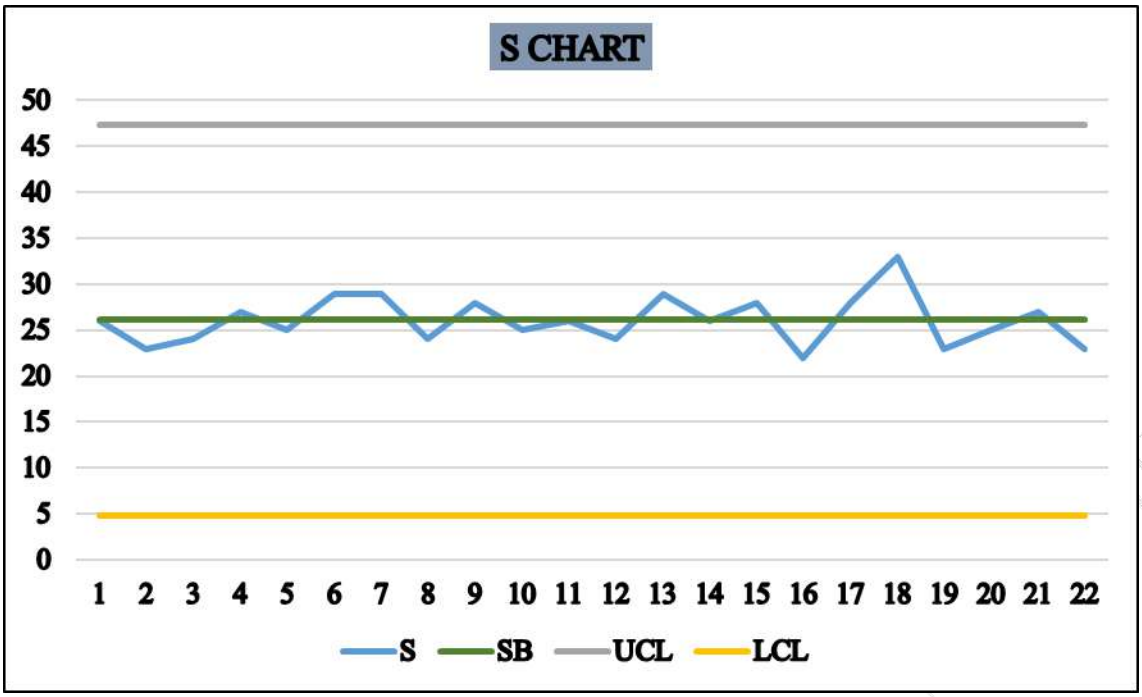
$= B_3 \times 26.09 \ (if \ B_3 = 0.185 \ for \ sample \ size \ 8)$

$= 0.185 \times 26.09 = 4.827$

Plotting the Control Chart using X bar – Chart



Plotting the Control Chart using X bar – Chart



We observed that from X Bar chart sub group 13 has the special (Out of Control) signal control, so we eliminate sub-group 13 and proceed for further inspection.

Know,

For X-Bar Chart

Control Limit, $\bar{\bar{x}} = \frac{\bar{x}_1+\bar{x}_2+\bar{x}_3+\cdots\ldots\ldots\bar{x}_k}{k}$

$$\bar{\bar{x}} = \frac{540 + 554 + 545 + 561 + 576 + 571 + 547 + 557 + 541 + 545 + 546 + 551 + 579 + 549 + 567 + 574 + 563 + 561 + 548 + 556 + 553}{22}$$

$$= \frac{12183}{21} = 553.77$$

$$\bar{\bar{x}} = 553.77$$

$$\bar{S} = \frac{\Sigma_1^k S_i}{k} = \frac{S_1 + S_2 + S_3 + \cdots S_{25}}{k}$$

$$\bar{S} = \frac{26+23+24+27+25+29+29+24+28+25+26+24+26+28+22+28+33+23+25+27+23}{21}$$

$$\bar{S} = \frac{574}{21} = 26.09$$

$$\bar{\bar{S}} = 26.09$$

$$UCL = \bar{\bar{X}} + A_3\bar{S}$$

$$UCL = 553.77 + (A_3 \times 26.09)\ (A_3 = 1.099 for\ sub\ group\ 8)$$

$$UCL = 553.77 + (1.099 \times 26.09)$$

$$\boldsymbol{UCL = 582.45}$$

$$LCL = \bar{\bar{X}} - A_3\bar{S}$$

$$LCL = 553.77 - (A_3 \times 26.09)\ (A_3 = 1.099\ for\ sub\ group\ 8)$$

$$LCL = 553.77 - (1.099 \times 26.09)$$

$$\boldsymbol{LCL = 525.10}$$

For Sigma (S) Chart

Control Limit, $\bar{S} = \frac{\Sigma_1^k S_i}{k}$

$$\bar{\bar{S}} = 26.09$$

$$UCL = B_4\bar{S}$$

$LCL = B_3\bar{S}$

$\bar{S}$ Chart:

Upper Control Limit, U.C.L. $= B_4\bar{S}$

$= B_4 26.09$ ($if\ B_4 = 1.815\ for\ sample\ size\ 8$)

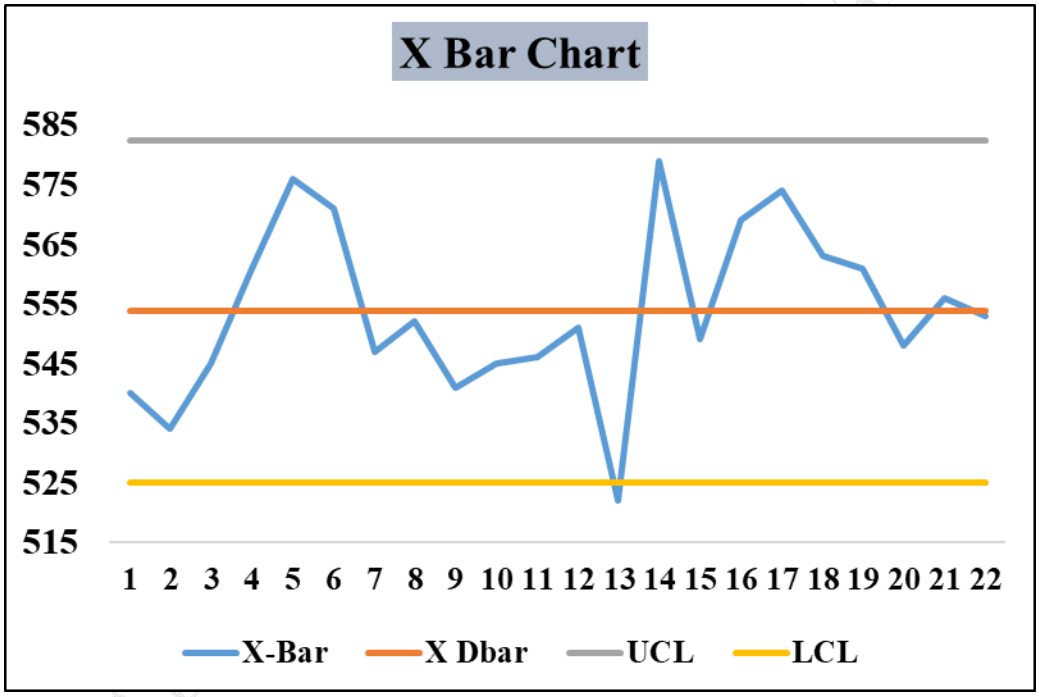
$= 1.815 \times 26.09 = 47.36$

Lower Control Limit, L.C.L. $= B_3\bar{S}$

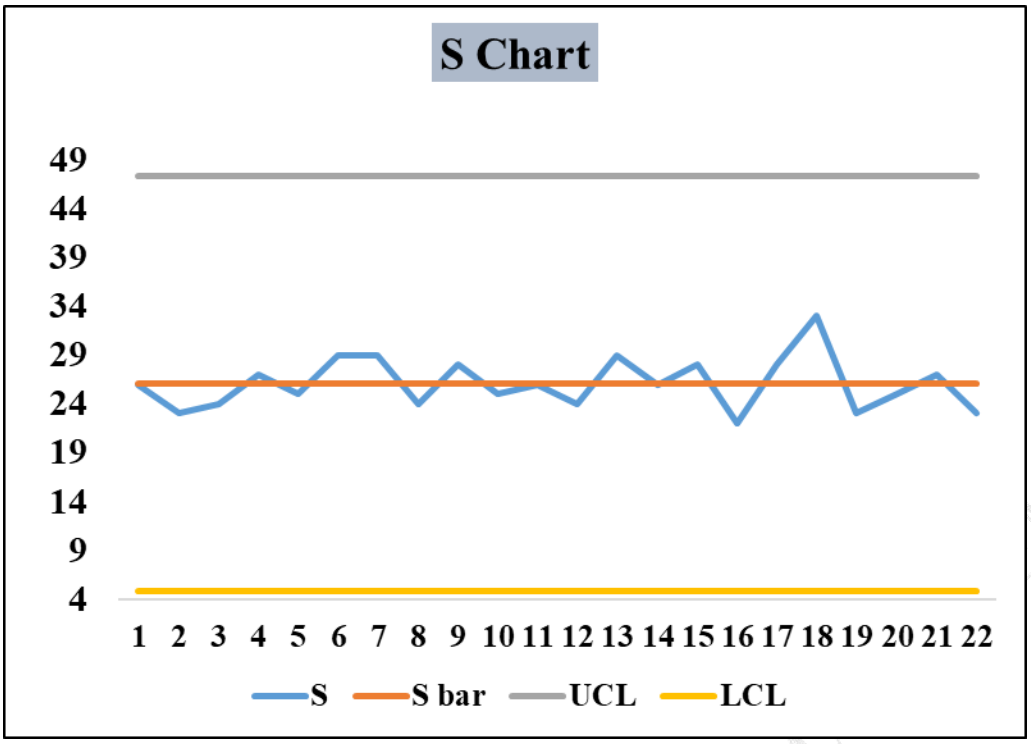
$= B_3 \times 26.09$ ($if\ B_3 = 0.185\ for\ sample\ size\ 8$)

$= 0.185 \times 26.09 = 4.827$

Plotting the Control Chart using X bar – Chart



Plotting the Control Chart using X bar – Chart



We observed that from X Bar chart sub group 13 has the special (Out of Control) signal control, so we eliminate sub group 13 and proceed for further inspection.

SAMPLING INSPECTION:

Sample: It is defined as the number of items or components, parts, drawn from a lot, batch or population (for inspection purpose)

Statistical method of obtaining representative data or observations from a group (lot, batch, population, or universe).

With a single grain of rice, an Asian housewife tests if all the rice in the pot has boiled; from a cup of tea, a tea-taster determines the quality of the brand of tea; and a sample of moon rocks provides scientists with information on the origin of the moon. This process of testing some data based on a small sample is called sampling.

Inspection: Any item or component or product which is manufactured is required to perform certain functions. The act of checking whether component or part actually does so or not is called inspection. In other words, inspection means checking the acceptability of the manufactured product.

Sampling: Sampling is an act of drawing samples from a batch on random basis. Sampling depends upon statistical probability and therefore samples must be collected from all sides and different depths of the box containing the lot or batch, so that every part has an equal chance of being selected. The samples should be collected at regular intervals (say every hour, every four hour, every day, selected).

Sampling Inspection: It is a technique to determine whether a lot or population should be rejected or accepted on the basis of the number of defective parts found in a random sample drawn from the lot.

TYPES ACCEPTANCE SAMPLING PLANS

1) Lot by Lot - Single Sampling

2) Lot by Lot - Double Sampling
3) Continuous Sampling
4) Sequential Sampling

2) <u>Lot by Lot - Single Sampling:</u>

- A lot size (N) of product is delivered to the quality check or inspection position.
- A sample size (n) is selected randomly from the lot.
- If the number of defects or defectives in the sample exceed the acceptance number (c or AN), the entire lot is rejected.
- If the number of defects or defectives in the sample does not exceed the acceptance number, the entire lot is accepted.
- Rejected lots are usually detailed 100% for the requirements that caused the rejection.
- In some cases the lot may be scrapped.
- Accepted lots are screened, rejected lots are sent to their destination. The rejected lots may be submitted for re-inspection.

Or

They are the number of items to be sampled (n) and a pre-specified acceptable number of defects (c). If there are fewer or equal defects in the lot than that of the acceptance number **c**, and then the whole batch will be accepted. If there are more than c defects, the whole lot will be rejected or subjected to 100% screening.

3) <u>Lot by Lot - Double Sampling:</u>

- A lot size (N) of product is delivered to the quality check or inspection position.
- Two sample sizes (n1, n2) and two acceptance numbers (c1, c2 or AN1, AN2) are specified.

A first sample of size n1 is taken.

- If the number of defects or defectives in the first sample exceed c1, the lot is rejected and a second sample is not taken.
- If the number of defects or defectives in the first sample do not exceed c1, the lot is accepted and a second sample is not taken.
- If the number of defects or defectives in the first sample are more than c1 but less than or equal to c2, a second sample n2 is selected and inspected.

If a second sample is inspected:

a) And defects or defectives in combined first and second sample do not exceed c2, the lot is accepted.
b) And defects or defectives in combined samples exceed c2, the lot is rejected.
   i. Rejected lots are detailed or scrapped.
   ii. Accepted lots and detailed rejected lots are sent to their destination

Or

Often a lot of items is so good or so bad that we can reach a conclusion about its quality by taking a smaller sample than would have been used in a single sampling plan. If the number of defects in this smaller sample (of size n1) is less than or equal to some lower limit (c1), the lot can be accepted. If the number of defects exceeds an upper limit (c2), the whole lot can be rejected. But if the number of defects in the n1 sample is between c1 and c2, a second sample (of size n2) is drawn. The cumulative results determine whether to accept or reject the lot. The concept is called double sampling.

4) Continuous Sampling:

- Continuous sampling is used where product flow is continuous and not feasible to be formed into lots.
- Two parameters are specified in a continuous sampling plan. The first is the frequency of checking f and the second is the clearing number i. The frequency f is expressed as 1/10, 1/20, 1/X, etc. and i is a number such as 20 or 50.
- When inspection begins, the product is checked 100% until i parts are found to be defect free. At this time, one out of X shall be inspected. If f = 1/10, then one out of 10 parts will be checked. The sampling will continue until a defect is found. When a defect is found, 100% inspection shall resume and the cycle starts over. When i parts are found to be defect free, the sample 1/X shall start again.
- In most cases, the inspector will not perform the 100% inspection. The inspector will mark the last sampled part and the manufacturing department will perform the 100% inspection or detailing operation.

5) Sequential Sampling:

- The inspector will select one part from the lot and check for the specified requirements.
- The part is classified as good or defective.
- A chart is specified for various sequential sampling plans. The required quality levels determine the acceptance, rejection, and continue sampling regions on the chart. The chart shows the inspector what decision to make after each sample is inspected. The lot will either be accepted rejected or another sample will be taken. This procedure is done on a lot by lot basis. The advantage of this type of sampling plan is that a decision could be made based on a relatively small sample.
- Rejected lots are detailed 100% (usually by the manufacturing department). Accepted and screened rejected lots are sent to their destination.

Or

Multiple sampling is an extension of double sampling, with smaller samples used sequentially until a clear decision can be made. When units are randomly selected from a lot and tested one by one, with the cumulative number of inspected pieces and defects recorded, the process is called **sequential sampling**

TOTAL QUALITY MANAGEMENT

INTRODUCTION

Total Quality Management (TQM) is a comprehensive concept and not related only to the quality of goods and services. It suggests that high quality standards (e.g., ISO 9000) should be maintained in other aspects of management such as production cost, marketing, sales promotion, etc. For such quality/efficiency in all aspects of business management, consciousness/awareness needs to be developed at all levels and among employees working in all departments of the enterprise. Employees must be motivated for maintaining high quality standards. In addition, their cooperation/involvement is necessary for maintaining efficiency in all aspects of business management. In brief, quality management is not the responsibility of management alone. Participation/involvement of both parties (management and employees) is essential for achievement of quality and other benefits.

The concept of TQM is closely related to the concept of quality circles which is very popular and also successful in Japan. Quality circles are work groups that meet frequently to study the ways and means to improve quality, reduce cost, eliminate wastages and solve other production problems. Here, employees are associated with quality, cost, efficiency, productivity, consumer service and satisfaction. This creates background for the concept of TQM.

TQM reflects the culture of an Organisation. It indicates consumer oriented, quality-oriented management philosophy. It is a commitment to quality by all managers and workers. TQM is a philosophy for achieving customer satisfaction which involves all - managers, employees and users. It is management by commitment and not management by control. This technique is to be introduced through quality circles. The route to TQM is through application of simple tools followed by Organisation change and culture change.

Total quality management is based on the following four powerful elements:

1) Focus on customer expectations,
2) Employee's involvement,
3) Mastery of process's
4) Team Work.

Focus on Customers:-Customers are the source of all the revenue that flows through the corporation. Their satisfaction keeps the money flowing especially in an open market where competitors are wooing them too. The focus of TQM is on customer satisfaction on quality, cost and delivery through improved organisational quality of processes. According to British Quality Association (BQA), TQM is a corporate business management philosophy which recognised that customer's needs and business goals are inseparable.

Employee Involvement:-Employees involvement is the most important recognised feature of TQM. In fact, quality is a team work of all employees. Their participation and co-operation are required to be taken at all levels. TQM is possible only through participative management. Under TQM, employees will be motivated to participate actively in the process of quality improvement through incentives and recognition of contribution for achieving quality standards.

Formation of Quality Improvement Teams:-A cornerstone of TQM is the team building that leads to commitment to improvement. Such teams include quality steering teams, corrective actions teams and so on. Such teams motivate employees and facilitate quality improvement.

Management's Involvement:-TQM is a systems approach in managing business and improving overall performance. It needs total commitment from the top management to provide viable leadership to the whole approach. Top level management has to take number of initiatives in order to start the process of TQM. In fact, TQM cannot have a good take off without total commitment of CEO and other senior executives.

BENEFITS OR ADVANTAGES OF TQM:

- **Customer Satisfaction:**-TQM is basically for the satisfaction and welfare of customers. Needs and expectations of customers are given special attention in TQM. The attention is on customers and zero defect goods will be supplied to them. As a result, there will be reduction in the complaints of consumers/customers. TQM is not for profit-making at the cost of customers but it is for giving satisfaction and welfare to them.
- **Quality Improvement:**-One major advantage of a TQM is quality improvement at all levels and in all activities. There is a systematic attempt to eliminate deficiencies such as production scrap or rework, customer complaints and material shortages. The cornerstone of any successful TQM system is the organised elimination of waste. The rejection rate in the production process will be low and this minimizes waste of materials and human efforts. Due to quality improvement, the sales and profits will also increase. The company will also develop goodwill and market recognition as supplier of quality goods.
- **Absence of Additional Investment:**-One advantage of TQM is that TQM does not require any additional investment. It improves operational quality as well as reduces cost. This technique is quite convenient to developing countries which are facing financial difficulties due to various reasons. TQM gives many benefits but without additional financial burden.
- **Raises Competitiveness:**-TQM technique is useful for raising quality and reducing costs. This naturally raises competitiveness in the domestic as well as global markets. TQM technique is useful for exports by raising global competitiveness.
- **Facilitates Expansion and Diversification:**-TQM leads to large turnover and high profits along with market reputation and consumer support. The company can use this profit for the execution of its expansion and diversification programmes. In brief, TQM facilitates expansion and diversification of business.
- **Provides Trained and Motivated Employees:**-TQM philosophy has its positive impact on employees. They are given proper training, monetary and non-monetary incentives, attractive working conditions and proper treatment. Workers take pride in manufacturing defect-free products.

Miscellaneous Advantages: TQM technique offers other advantages as noted below:

- Long-term consumer support,

- ❖ Prestigious position in international marketing,
- ❖ High standard of living to employees, and
- ❖ Cost control.

ZERO DEFECTS

Introduction

Philip B. Crosby was an eminent Quality Guru, born in 1926, began his quality career as a reliability engineer. He later participated in the Martin missile experience that spawned the genesis of the Zero Defect movement. He worked in Quality Management for 14 years in ITT as a Corporate Vice President and Director Quality. In 1974 he published Quality is Free, which became a bestseller. In response to the interest shown in the book, he left his organization that year to set up Philip Crosby Associates Incorporated.

Philip B. Corsby published his second best seller, Quality without Tears, in 1979. Other books associated with his name are

- ❖ The Art of Getting Your Own Sweet Way
- ❖ More Things
- ❖ The Eternally Successful Organization and Leading
- ❖ The Art of Becoming and Executive

Do It Right First Time (DIRFT) and Zero Defect

Corsby is very much popular for these two concepts named as **Do It Right First Time and Zero Defects**.

The concept of Zero Defect (ZD) promotes a constant, conscious desire to do a job right the first time [Halpin, 1966], where the performance of the individual have a crucial role. A way to efficient performance is by constant awareness; where the workers task is important, the product the worker is working on is important and the effort by the worker is not neglected by the management. To strive against the concept Zero Defect five requirements must be fulfilled. In theory it describes the ideal state but in reality the process is confronted with different kinds of disturbances increasing the risk of errors in manufactured products.

1) The right Sourcing – Concerning the quality of the purchased components, products or material.
2) The right Process and Technology – Accentuate the requirements on accomplishing key activities i.e. Process Improvement and Tooling Management.
3) The right Service and Support Systems – Focusing on support functions in manufacturing channels or cells.
4) The right People – Educating and developing personnel, competent staff can prevent more that defects occurs comparing to the installation of a new process or device.
5) The right Organization and Methods – Concentrate on the organization and management that operates the manufacturing process. Careful guidance and directions to increase efficiency of the employee on a day to day basis.

DEFINITION

It is a management tool aimed at the reduction of defects through prevention. It is directed at motivating people to prevent mistakes by developing a constant, conscious desire to do their job right the first time."

"The quality manager must be clear, right from the start, that zero defects is not a motivation program. Its purpose is to communicate to all employees the literal meaning of the words 'zero defects' and the thought that everyone should do things right the first time."

Corsby **defined the quality as the conformance** to the requirements which the company itself has established for its products based upon the customer's needs. He believes that most companies have systems that allow deviation from actual requirement. The cost that they spend on doing the wrong things right in subsequent chances is 20% of their revenue in manufacturing companies and 35% of operating expenses for service companies. He believed that workers should not be the prime responsible for the poor quality, in fact Management set the standard of quality and workers follow them therefore the initiative comes from the top. Doing things right first time will not prevent people from making mistakes, but will encourage everyone to improve continuously. He strongly emphasized on the top- down approach, since he believes that senior management is entirely responsible for quality. The ultimate goal is to train all the staff and give them the tools for quality improvement, to apply the basic precept of Prevention Management in every area.

PRINCIPLES OF ZERO DEFECTS

Quality is conformance to requirements:-Every product or service has a requirement according to the customer needs. If these requirement are achieved by the product when comes to use of the customer then this product categorize as the quality product. for example if low cost Ink pen full fill the requirement of writing without any blot and skip on the paper then it is called the quality product in comparison of the a precious gold plated pen if it will not write good and neat on the paper. Hence if a product meets the requirement of the customer then it conforms the quality of the product, no matter how costly it is.

Defect prevention is preferable to quality inspection and correction:-It is better to prevent the defect at its origin rather to inspect it in the process and then correct it. It saves lot of human power and cost of inspection and correction. For example If a person changes the poor condition brake shoes of his bike before next riding then it will prevent lot of energy of the rider and reduce the risk of accident on the road and generation of new defect in the bike due to poor condition brake shoes which observed later and needs the correction and in turn of high cost of repair.

Standard of Quality is always be ZERO DEFECT, not close enough:-If any product does not meet the requirements then the product is not the quality product even if it close to meet the requirement, because on the basis of Zero Defect any non-conformance is not, for granted. The product is not acceptable and categorize as under quality product.

Quality is measure on the basis of Price - Price of Non Conformance (PONC):-This is the key principle, Crosby's believed that every defect incur a cost. To find and correct and prevent this defect organization introduces many steps like Inspection, Time, Rework, Scrape, Collection of data of customer satisfaction etc. All these steps required a huge amount of money and so lot of revenue has lost to maintain all steps to prevent the defects and therefore to maintain the Quality, cost must considered. Every non-conformance contributes a cost in terms of loss of revenue due to it.

QUALITY CIRCLE (QC)

INTRODUCTION

Quality Circles are usually characterized as small, voluntary groups of employees set up to meet periodically for such practical purposes as: Pinpointing, examining, analyzing and solving problems in areas including knowledge management, innovation, work relations, quality, productivity, safety, cost, etc.

Enhancing communication between employees and management on the above areas Quality Circles can only thrive if management will take action on the recommendations of the Circle. When the management has no interest in participation as is often the case, the Circles simply disintegrate.

Dewar, President of the International Association of QCs, defines QCs as "a way of capturing the creative and innovative power that lies within the work force"

A quality circle is a small group of volunteers (usually 3 to 12 employees) doing similar work. They meet regularly under the leadership of their immediate supervisor, or some one chosen among the circle to identify problems, set priorities, discover causes and propose solutions. These may concern quality, productivity, safety, job structure, process flow, control mechanism, aesthetics of the work area etc.

According to Maurice Alston,

"Quality Circles are small groups of people doing similar work who, together with their supervisors volunteer to meet for an hour a week to study and solve work related problems which affect them. Circle leaders and members are trained in simple problem solving techniques which identify causes and develop solutions. At an appropriate time, presentations are made by the quality circles to the management who decide whether to accept, modify or decline the proposals"

Quality Circle is a participative management system in which workers make suggestions and improvements for the betterment of organisation

DEFINITION:

A Quality Circle typically is a small group of volunteers consisting of first-line employees who meet regularly to identify, analyze and solve problems in their area of work to continually improve the quality, productivity and related issues of their work, products and services. These Small groups:-Operate autonomously, Utilize quality control Concepts and Techniques and other Improvement tools, Tap members' creativity and promote self and mutual development. The Size of the QC group should be 7(max.) including facilitator (No. of executives in the QC group should not exceed 2 including facilitator). It can be more than two, for the departments where executive strength is considerably more.

CONCEPT OF QUALITY CIRCLE:

The Quality Circle concept has three major attributes; these are:

1) QC is a form of participative management.
2) QC is a human resource development technique.
3) QC is a problem solving technique.

OBJECTIVES OF QUALITY CIRCLES:

- To improve the quality and productivity and thus contribute to the improvements and development of the enterprise.
- To reduce the cost of products or services by waste reduction, safety, effective utilisation of resources, avoiding unnecessary errors and defects.
- To identify and solve work related problems those interfere with production.
- To tap the creative intelligence of the persons working in the organization and to make full use of its human resources.
- To permit employees to develop and use greater amount of knowledge and skill and motivate them to apply to a wide range of challenging tasks.
- To improve communication within the organization.
- To increase employees' loyalty and commitment to the organization and its goals.
- To respect humanity and build a happy bright work place environment which is meaningful to work in.
- To enrich human capability, confidence, moral, attitude and relationship.
- To satisfy the human needs of recognition, achievement and self-development.

ADVANTAGES OF QUALITY CIRCLES:

- Promote high level of productivity and quality-mindedness.
- Self and mutual development of employees.
- Creating team spirit and unity of action.
- Increased motivation, job satisfaction and pride in their work.
- Reduced absenteeism and labour turnover.
- Developing sense of belongingness towards a particular organization.
- Waste Reduction.

- Cost reduction.
- Improved communication.
- Safety improvement.
- Increased utilization of human resource potential.
- Enhancement in consciousness and moral of employees through recognition of their activities.
- Leadership development.
- Trained staff.

DISADVANTAGES/PROBLEMS WITH QC:

- Inadequate Training
- Unsure of Purpose
- Not truly Voluntary
- Lack of Management Interest
- Quality Circles are not really empowered to make decisions.

ISO QUALITY SYSTEM:

It is the system that an organisation uses to manage the quality of their services or products. Quality management systems are only one type of management system; other examples include financial management systems, safety management systems and environmental management systems.

The official definition of a quality system from **ISO** (the International Organization for Standardization) is *"The management system used to direct and control an organization with regard to quality".* But that's a bit of a mouthful, and not overly clears (as with many of their definitions).

Think of it as the system that your company uses to plan, create, develop, make and/or deliver your services or products.

A quality management system consists of various elements.

ISO 9001 groups them into 4 categories:

⇒ ***Management:*** Planning, goals & objectives, reviewing progress.

⇒ ***Resources:*** People, tools, equipment etc.

⇒ ***Services or Products "realization"*:** Whatever is involved in creating or delivering them, and lastly the

⇒ ***Monitor, Measurement & Checking*:** The all-important feedback loop.

Quality is something every company strives for and is often times very difficult to achieve. Complications concerning efficiency and quality present themselves every day in business, whether an important document cannot be found or a consumer finds a product not up to their expectations. How can a company increase the quality of its products and services? The answer is ISO 9000.

As standards go, ISO 9000 is one of the most widely recognized in the world. ISO 9000 is a quality management standard that presents guidelines intended to increase business efficiency and customer

satisfaction. The goal of ISO 9000 is to embed a quality management system within an organization, increasing productivity, reducing unnecessary costs, and ensuring quality of processes and products.

ISO 9001:2008 is applicable to businesses and organizations from every sector. The process oriented approach makes the standard applicable to service organizations as well. Its general guidelines allow for the flexibility needed for today's diverse business world.

ISO 9000 PRINCIPLES:

A Customer Focus:-As stated before, the customer is the primary focus of a business. By understanding and responding to the needs of customers, an organization can correctly targeting key demographics and therefore increase revenue by delivering the products and services that the customer is looking for. With knowledge of customer needs, resources can be allocated appropriately and efficiently. Most importantly, a business's dedication will be recognized by the customer, creating customer loyalty. And customer loyalty is return business.

Good Leadership:-A team of good leaders will establish unity and direction quickly in a business environment. Their goal is to motivate everyone working on the project, and successful leaders will minimize miscommunication within and between departments. Their role is intimately intertwined with the next ISO 9000 principle.

Involvement of People:-The inclusion of everyone on a business team is critical to its success. Involvement of substance will lead to a personal investment in a project and in turn create motivated, committed workers. These people will tend towards innovation and creativity, and utilize their full abilities to complete a project. If people have a vested interest in performance, they will be eager to participate in the continual improvement that ISO 900 facilitates.

Process Approach to Quality Management:-The best results are achieved when activities and resources are managed together. This process approach to quality management can lower costs through the effective use of resources, personnel, and time. If a process is controlled as a whole, management can focus on goals that are important to the big picture, and prioritize objectives to maximize effectiveness.

Management System Approach:-Combining management groups may seem like a dangerous clash of titans, but if done correctly can result in an efficient and effective management system. If leaders are dedicated to the goals of an organization, they will aid each other to achieve improved productivity. Some results include integration and alignment of key processes. Additionally, interested parties will recognize the consistency, effectiveness, and efficiency that come with a management system. Both suppliers and customers will gain confidence in a business's abilities.

Continual Improvement:-The importance of this principle is paramount, and should a permanent objective of every organization. Through increased performance, a company can increase profits and gain an advantage over competitors. If a whole business is dedicated to continual improvement, improvement activities will be aligned, leading to faster and more efficient development.

Ready for improvement and change, businesses will have the flexibility to react quickly to new opportunities.

Factual Approach to Decision Making:-Effective decisions are based on the analysis and interpretation of information and data. By making informed decisions, an organization will be more likely to make the right decision. As companies make this a habit, they will be able to demonstrate the effectiveness of past decisions. This will put confidence in current and future decisions.

Supplier Relationships:-It is important to establish a mutually beneficial supplier relationship; such a relationship creates value for both parties. A supplier that recognizes a mutually beneficial relationship will be quick to react when a business needs to respond to customer needs or market changes. Through close contact and interaction with a supplier, both organizations will be able to optimize resources and costs.

SIX-SIGMA:

EVOLUTION OF SIX SIGMA:

- The concept of Six -Sigma quality evolved Motorola Corporation USA in late 70's.
- **Mikel J. Hary,** introduced the concept of Six Sigma to Motorola. It based on statistics.
- Its evolution was the result of **Bob Galvin's expectations the CEO of Motorola Corporation** in 1981 in order to effect a tenfold improvement in product failure levels over a 5 year period.
- **Bill Smith**, an engineer of company, who is now called father of Six-Sigma conducted a statistical correlation between life of the product and the defect detected during the manufacturing of the product.
- He conducted that if a product has been found defective and corrected during the production process, chances were high that other defects had been missed and would show up later during usage.
- **Mikel J. Hary** suggested that breaking down and studying processes is a key element of result oriented quality programs. This helps in tracking down the root cause of defects.
- Hence Six Sigma was evolved by **Bill Smith and Mikel J. Hary** as a 6 Step methodology with focus on defect reduction and improvement in yield through statistics.
- UN till 1994, Six Sigma remains within the boundary of Motorola. Motorola reported $16 billion saving in 10 years of implementation of Six Sigma. Outer world know about Six- Sigma but not how to implement it. Now it has adopted by approx. more 50% organization in the world.

WHAT IS SIGMA?

- We all know about the average and also working with it in professional as well as general life like average income, average height, average marks, average weight etc. This average is the number which represents whole group of numbers and can be find out as follows **Average or Mean Value=(Sum of all values / No. of values)**
- Each value in the group has certain distance from the mean value. This distance is called the deviation of the value from its mean.
- When we calculate the deviation for the whole group we call it **Standard Deviation or Sigma.**

- Hence Sigma represents the **Standard Deviation** which is used to measure the spread of any process from its mean value.
- If the value of Sigma increases this means the deviation of the process from the mean value increases. Therefore the value of Sigma must be as low as possible.

STANDARD DEVIATION (σ):

Standard deviation is defined as the square root of the arithmetic mean of the squares of the deviation of the values taken from the mean and is calculated as follows

$$\sigma = \sqrt{\frac{\Sigma(X - \bar{X})^2}{N}}$$

Also called root mean square deviation and denoted by small Greak letter **"σ"** and read as sigma.

SIX-SIGMA SCALE

One more important thing is the number in front of Sigma tells the Sigma level. As much as the process comes in our control the possibility of defect occurrence goes down and Sigma level goes up. Hence at Six Sigma level the possibility of defect occurrence is very low. The fig. of Six Sigma Scale shown below explains clearly.

Six Sigma Scale

Sigma Level	Defect Rate (PPM)	Yield in %	Cost of Poor Quality (% of Sales)	Competitive Level
6σ	3.4	99.99966	<10%	World Class
5σ	233	99.9767	10 to 15%	
4σ	6210	99.3790	15 to 20%	Industry Average
3σ	66807	93.3193	20 to 30%	
2σ	308537	69.1462	30 to 40%	Non-Competitive
1σ	690000	.....	74%	

WHY SIX SIGMA FOUND PLACES SO QUICKLY?

After open to the world Six-Sigma fixed its place very quickly. It has a strong reason which shown in the Six Sigma scale. Some of them are mentioned below.

- It is result oriented.
- It makes the organization more competitive.
- It increases the customer satisfaction.

- ❖ It is cost saving.
- ❖ It smooth's the process.
- ❖ It reduces the defect occurrences.

Above all Six Sigma counted the defect in number per million rather in percentage. I would like to clear it by this example. Suppose Vendor A and Vendor B offers to supply the cap of a pen to a pen manufacturing company Say 'C'. Vendor A commit that the Lot of Caps he will send has 99.3790% pcs OK and Vendor B commit that the lot he will send has 99.9767 % pcs OK but he will charge little more than the Vendor A. Which Vendor will be selected by the Manufacturer C? If cost is taken into consideration then Vendor A will be selected because in terms of OK percentage it is very small difference but on the basis of Six Sigma Vendor A supplying 6210 defective pcs per million and working at 4Sigma level while Vendor B supplying 233 defective pcs per million and working on 5 Sigma level. So the difference of defective pcs are very high but it is not reflected in percentage scale and for every defective pc of Cap the pen manufacturer has to bear the cost of defective pen which in turn will go very high. So on the basis of Six Sigma Scale the Manufacturer should select the Vendor B. This will certainly save the cost and reduce the customer complaints of the manufacturer and return a high profit margin and goodwill.

Few Definitions for Six-Sigma

"In layman language , Six Sigma is 3.4 defects per million i.e. if an organization produces 1 million of its products and 3.4 pcs are found defective out of 1 million then the organization follows the 6 Sigma standard, defects per million is the indicator of Six Sigma standard."

Few more advanced definitions are below

According to Dr. Mikel J. Harry, CEO of Six Sigma Academy, Phoenix USA:

1) Six-Sigma is a statistical measurement, which helps us establish our course and gauge our pace in the race for total customer satisfaction. It tells us how good our products, services and processes really are. It allows us to draw comparisons with other similar or dissimilar products, services and processes. We can see where we need to go and what we must do to get there.
2) It is a business strategy which makes the customers more satisfied. It can greatly help us to gain competitive edge. This is because, as we improve the sigma rating of the process, the product quality improves and costs go down.
3) It is a philosophy. It is an outlook, a way that we perceive and work within the business world around us. Essentially, the philosophy is one of working smarter, not harder. This translates to making fewer and fewer mistakes in everything we do. from the way we manufacture products to the way we fill out a purchase order. As we discover and neutralize harmful sources of variation, our sigma rating goes up. Again this means our process capability improves and the defects (mistakes) go away.

According to Mr. Jack Weich, the CEO of the General Electric Co., USA:

1) Six-Sigma is a disciplined Quality Improvement methodology that focuses om moving every process that touches the customers --every product and service--towards near perfect quality. It is measure of the company's quality.
2) Six Sigma is more than a quantitative statistical measure of processes; it embraces every aspect of work, using a disciplined, fact based approach to problem--solving. It is a new way of thinking about work and customer value. It is also a powerful force to create one corporate culture, some of it is bureaucracy busting -pushing down decision -making to lowest practical levels, empowering employees. At the other end i.e. more complicated challenges-including lean manufacturing initiatives and variability reduction.

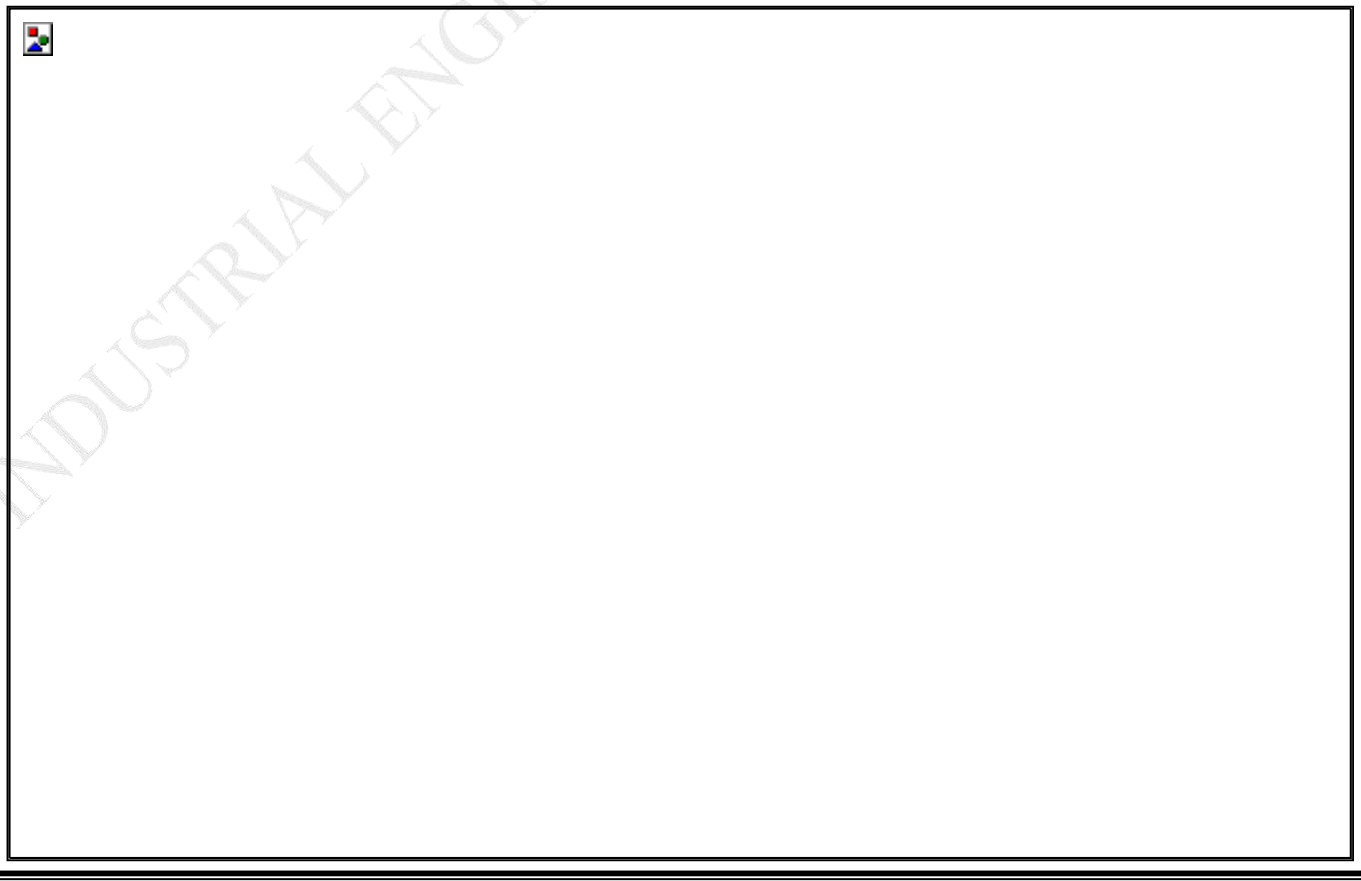
For successful implementation of Six Sigma, the company should be:

- ❖ Open to change
- ❖ Hungry to learn
- ❖ Anxious to move quickly to good Idea.

IMPLEMENTATION/PROCESS OF SIX-SIGMA:

Six-Sigma is implemented by the **DMAIC** methodology which mentioned here. The fig. shows the **DMAIC** Stair i.e. the Steps of **DMAIC methodology** through which the Six Sigma project progress. The Steps are

1) Define
2) Measure
3) Analysis
4) Improve
5) Control



Understanding DMAIC methodology

DMAIC methodology is the way through which the Six Sigma project progress. All steps of DMAIC methodology is explained briefly as below.

- **Define:**-Define is the first step in which the problem/opportunity is clearly identified. If the problem is solved or get rid then how much benefit to the organization in terms of profit margin or cost saving?
- **Measure:**-The second step is ranking of opportunities on basis of risk priority i.e. impact and effort.
- **Analysis:**-This is the step at which new goals are set and the road are prepared for cover the distance from the current level to the target level. Statistical tools as well as conventional quality techniques like Brainstorming, Root -cause Analysis, Fishbone Diagram, Pareto analysis etc. may be used for carrying out the analysis.
- **Improvement:**- At this step we measure how much we improve from our current sigma level and how much we have to improve to achieve the desired level.
- **Control:**-This is the last step here we record all improvements and parameters otherwise we lost the control over the target achievement and go back to previous stage. So control means document the all parameters and makes it as a new system.

The objective of **Six Sigma quality** is to reduce process output variation so that on a long term basis, which is the customer's aggregate experience with our process over time, this will result in no more than **3.4 defect parts per million (i.e. 10 lakhs) (PPM) opportunities (or 3.4 defects per million opportunities – DPMO). F**or a process with only one specification limit (upper or lower), this results in six process standard deviations between the mean of the process and the customer's specification limit (hence, Six Sigma). For a process with two specification limits (upper and lower), this translates to slightly more than six process standard deviations between the mean and each specification limit such that the total defect rate corresponds to equivalent of six process standard deviations.

ADVANTAGES OF SIX-SIGMA:

(1) Six Sigma is driven by the customer and thus aims to achieve maximum customer satisfaction and minimizing the defects. It targets the customer delight and new innovative ways to exceed the customer expectations.

(2) Implementation of Six Sigma methodology leads to rise of profitability and reduction in costs. Thus improvements achieved are directly related to financial results.

(3) Six Sigma is successfully implemented in virtually every business category including return on sales, return on investment, employment growth and stock value growth.

(4) Six Sigma targets Variation in the processes and focuses on the process improvement rather than final outcome.

(5) Six Sigma is prospective methodology as compared to other quality programs as it focuses on prevention on defects rather than fixing it.

(6) It is attentive to the entire business processes and training is integral to the management system where the top down approach ensures that every good thing is capitalized and every bad thing is quickly removed.

DISADVANTAGES OF SIX-SIGMA:

(1) Applicability of Six Sigma is being argued among the Six Sigma critics. They opined that the quality standards should be according to specific task and measuring 3.4 defects per million as standard leads to more time spent in areas which are less profitable.

(2) Six Sigma gives emphasis on the rigidity of the process which basically contradicts the innovation and kills the creativity. The innovative approach implies deviations in production, the redundancy, the unusual solutions, insufficient study which are opposite to Six Sigma principles.

(3) People argue that Six Sigma is a bit gimmicky and simply a rebranding of the continues improvement techniques and tools as practiced by Toyota. It thus promotes outsourcing of improvement projects with lack of accountability.

(4) Six Sigma implementation constantly require skilled man force. Thus control and employee dedication are hard to accomplish if it is not implemented regularly.

(5) While converting the theoretical concepts into practical applications there are lot to real time barriers which needs to be resolved.

IMPORTANT QUESTIONS IN UNIT - IV FROM PREVIOUS QUESTION PAPERS

1. Explain SQC with advantages, limitations and applications. [7M] April- 2015 Set 1
2. What is the importance of quality control? Explain. [8M] April- 2015 Set 1
3. Explain the concept of zero defects. [7M] April- 2015 Set 1
4. What is the prominence of ISO quality system? [8M] April- 2015 Set 1
5. Define the concept of inspection and explain various types of inspections. [7M] May/June-2015 Set 1
6. Define control charts. What are the objectives and importance of control charts? [8M] May/June-2015 Set 1
7. Define quality circles. Explain its features and objectives. [8M] May/June-2015 Set 1
8. Define Six-sigma. State its features and objectives. [7M] May/June-2015 Set 1
9. Define statistical quality control? Explain the significance and advantages of statistical Quality control? [7M] May/June-2015 Set 2
10. How do you draw inferences from a control chart? How can you improve the process by using control charts? [8M] May/June-2015 Set 2
11. Write about ISO and explain the benefits of ISO registration. [8M] May/June-2015 Set 2
12. Discuss in detail the various applications of quality circle in the maintenance of quality production. [7M] May/June-2015 Set 2
13. Define acceptance sampling. What are the various methods of acceptance sampling? [8M] May/June-2015 Set 3
14. Discuss in detail the applications of control charts. [7M] May/June-2015 Set 3
15. Briefly explain the structure of quality circles. [8M] May/June-2015 Set 3
16. Write the advantages and disadvantages of Six-Sigma. [7M] May/June-2015 Set 3
17. Define quality. Explain the importance of quality in the changing techno-economic scenario. [8M] May/June-2015 Set 4
18. Explain the parameters affecting acceptance sampling plans. [7M] May/June-2015 Set 4
19. Write in detail about the step by step implementation of a quality circle. [8M] May/June-2015 Set 4
20. Explain zero defect? How do you develop Hassle-free organisation with zero defect programme? [7M] May/June-2015 Set 4
21. Define 'Quality' and explain the factors that influence the quality of a product. [7M] Dec – 2015 Set 1
22. Discuss the importance of quality in the changing techno economic scenario. [8M] Dec – 2015 Set 1
23. Define TQM. What are the essential elements of TQM? [8M] Dec – 2015 Set 1
24. Explain the benefits of TQM. [7M] Dec – 2015 Set 1
25. State the importance of Quality control. [4M] April - 2016 set 1

26. Explain the need and procedure for conducting work sampling study. [4M] April - 2016 set 1

27. The following table gives the coded measurement obtained from 20 subgroups of 5 each:

Subgroups No.	Statistics				
Groups	**1**	**2**	**3**	**4**	**5**
1	-1	2	1	0	1
2	2	0	1	0	1
3	1	1	0	0	1
4	2	1	0	-1	0
5	1	-1	0	0	-1
6	-1	-1	2	0	2
7	-1	-1	0	-2	1
8	1	1	2	-1	0
9	2	1	-1	0	0
10	-2	1	-2	2	1
11	0	1	-3	2	1
12	2	1	-1	0	0
13	0	1	-3	2	1
14	0	0	-1	0	1
15	-1	2	1	1	2
16	1	-1	2	0	2
17	2	1	-1	0	0
18	2	0	1	0	1
19	0	1	1	-1	1
20	3	-3	1	1	1

i. Construct the $\bar{X}$ and R charts and plot the points on the chart.

ii. What will be the control limits on $\bar{X}$ and R charts for immediate future?

iii. Estimate the value of σ. [8M] April - 2016 set 1

28. Explain in detail about the need of ISO quality systems in an industry. [8M] April - 2016 set 1

29. Explain the term TQM. [4M] April - 2016 set 2

30. Construct (X Bar) and R-charts for the following information and state whether the process is in control. For each of the following, (X Bar) has been computed from a sample of 5 units drawn at an interval of 1 hour from an ongoing manufacturing process. [8M] April - 2016 set 2

S.No.	X_1 (10 AM)	X_2 (11 AM)	X_3 (12 PM)	X_4 (01 PM)	X_5 (02 PM)
1	10.02	10.15	9.85	10.02	9.97
2	9.97	9.98	9.96	9.92	10.05
3	10.08	10.02	10.1	10	10.01
4	9.92	10.12	10.08	10.02	10.05

5	10.02	10.06	10.04	9.95	9.89

31. Explain six sigma concept. How do you think that this concept would improve the productivity?

[8M] April - 2016 set 2

32. Define zero defect concept. [4M] April - 2016 set 3

33. Construct control chart X Bar - R for the following data on the basis of 12 samples collected from a process, 5 data points are taken every hour. Comment on the state of control, assuming that these are the first data. What will be future control limit? [8M] April - 2016 set 3

1	2	3	4	5	6	7	8	9	10	11	12
42	42	19	36	42	51	60	18	15	69	64	61
65	45	24	54	51	74	60	20	30	109	90	78
75	68	80	69	57	75	72	27	39	113	93	94
78	72	81	77	59	78	95	42	62	118	109	109
87	90	81	84	78	132	138	60	84	153	112	136

34. What is Quality circle? How the implementation of Quality circle enhance the Production?

[8M] April - 2016 set 3

35. Define SQC. [3M] April - 2016 set 4

36. The following data (two subgroup of size 4), is from two different machines which are supposed to be alike. Plot the necessary chart to show whether their product would support this assumption. If they don't, does this prove the machines are not essentially alike? [8M] April - 2016 set 4

Machine 1			**Machine 2**		
Subgroup	**Average**	**Range**	**Subgroup**	**Average**	**Range**
1	2.77	0.06	1	2.53	0.12
2	2.70	0.29	2	2.67	0.30
3	2.78	0.19	3	2.66	0.17
4	2.67	0.12	4	2.57	0.25
5	2.75	0.34	5	2.60	0.24
6	2.77	0.23	6	2.60	0.05
7	2.75	0.17	7	2.70	0.30
8	2.73	0.06	8	2.56	0.04
9	2.76	0.23	9	2.70	0.19
10	2.63	0.20	10	2.67	0.08
11	2.73	0.17	11	2.60	0.11
12	2.74	0.28	12	2.63	0.14
13	2.73	0.26	13	2.71	0.24

14	2.72	0.13	14	2.63	0.31
15	2.73	0.13	15	2.75	0.17

37. Describe the key steps involved in the process of getting registered to ISO 9000 certification.

[8M] April - 2016 set 4

38. The following data were obtained over a 5-day period to indicate X and R chart for a quality characteristic of a certain manufacturing product that had required a substantial amount of rework. All the figures apply to the product made on a single machine by a single operator. The sample size was 4. Two samples were taken per day. Comment on the process using X and R charts. [15M] Nov/Dec 2016 set 1

Sample No.	Observation's			
	1	2	3	4
1	11	12	13	10
2	6	10	10	11
3	11	12	9	12
4	14	10	8	13
5	12	11	11	10
6	11	10	10	12
7	10	12	13	13
8	10	11	11	10
9	12	13	11	12
10	11	13	9	9

39. State and explain the concept of six sigma with suitable examples [15M] Nov/Dec 2016 set 1

40. What are quality circles and explain the purpose of it. [4M] Nov/Dec 2016 set 1

41. What is the philosophy of TQM? [9M] Nov/Dec 2016 set 1

42. Comment on single and double sampling plans and their applications. [7M] Nov/Dec 2016 set 1

43. The following data were obtained over a 5-day period to indicate X and R chart for a quality characteristic of a certain manufacturing product that had required a substantial amount of rework. All the figures apply to the product made on a single machine by a single operator. The sample size was 3. Two samples were taken per day. Comment on the process using X and R charts. [15M] April - 2017 set 1

Sample No.	Observation's		
	1	2	3
1	11	8	8
2	10	12	13
3	10	12	12

4	12	13	11
5	10	13	7
6	10	12	13
7	7	10	8
8	11	12	9
9	10	9	8
10	8	11	11

44. Explain the applications of quality circles in management. [8M] April - 2017 set 1
45. Briefly explain the concept of six sigma. [7M] April - 2017 set 1
46. Explain the concept of Zero defect. [4M] April - 2017 set 1
47. What do you understand from process control? Explain. [8M] April - 2017 set 1
48. State the benefits and limitations of TQM. [8M] April - 2017 set 1
49. Give a brief note on quality circles. [4M] April - 2017 set 2
50. Define control chart and state the objectives of X and R charts. [8M] April - 2017 set 2
51. Describe the various elements of TQM in brief. [8M] April - 2017 set 2
52. Explain Six Sigma concept [4M] April - 2017 set 3
53. Describe the method of constructing X and R chart and explain how these charts help in determining lack of control. [8M] April - 2017 set 3
54. Define TQM. State the guiding principles of TQM. [8M] April - 2017 set 3
55. Explain the importance of quality control. [4M] April - 2017 set 4
56. Explain the theory underlying control charts for fraction defective. [8M] April - 2017 set 4
57. What is meant by process capability? How will you determine the same? [8M] April - 2017 set 4
58. Describe the method of constructing X and R chart and explain how these charts help in determining lack of control. [7M] Nov - 2017 set 1
59. Define the concept of inspection and explain various types of inspections. [8M] Nov - 2017 set 1
60. Explain the applications of quality circles in management. [7M] Nov - 2017 set 1
61. Briefly explain the concept of six sigma. [8M] Nov - 2017 set 1
62. What is SQC and list out its benefits? [4M] Nov - 2017 set 1
63. What are quality circles and explain the purpose of it. Explain how it is beneficial to organization. [8M] Nov - 2017 set 1
64. Explain the objectives of ISO quality systems and discuss the major clauses in it. [8M] Nov - 2017 set 1
65. What is quality control? How is it different from inspection? [3M] April - 2018 set 1
66. Define quality and explain the factors that influence the quality of a product. [8M] April - 2018 set 1
67. The following table gives the number of defects in a casting used for making crank case of diesel engine.

Casting No.	1	2	3	4	5	6	7	8	9	10
No. of Defects	15	11	25	10	12	20	15	10	17	13

Construct an appropriate control chart with the control limits and comment on the process.

[8M] April - 2018 set 1

68. Explain the significance of statistics in quality control? [4M] April - 2018 set 2

69. In a manufacturing unit, a sample of 5 sheets is taken every one hour. The data collected from the measurement of thickness of these sheets is tabulated below: [10M] April - 2018 set 2

Sample No.	Thickness in mm for 5 sheets				
	I	II	III	IV	V
1	25	31	22	26	24
2	32	31	30	34	33
3	35	34	33	32	32
4	26	25	29	30	25
5	33	34	30	29	33
6	34	32	31	28	27

Draw the control chart for mean and range, and establish whether the process is under control?

70. Write about ISO and explain the benefits of ISO registration? [6M] April - 2018 set 2

71. Write about quality circles. [4M] April - 2018 set 3

72. Gopal industries want to set-up a control chart for the number of defective units for its toaster production line. 25 Random samples of 400 units each inspected and the number of defective units in each sample were noted as follows. Draw suitable control for the data. [8M] April - 2018 set 3

Sample No.	No. of Defectives	Sample No.	No. of Defectives
1	17	14	19
2	26	15	19
3	22	16	8
4	24	17	8
5	30	18	23
6	35	19	20
7	15	20	18
8	19	21	18
9	23	22	13
10	18	23	20
11	15	24	14
12	21	25	17

73. What is the need for ISO 9000 standards? What are the various certifications under this umbrella of ISO 9000? Explain. [8M] April - 2018 set 3

74. What is quality control? How is it different from inspection? [4M] April - 2018 set 4

75. Define total quality management? Describe the various elements of TQM in brief.[8M] April - 2018 set 4

76. Define control chart and state the objectives of *X Bar* and R charts [8M] April - 2018 set 4

77. What is quality control? [4M] Nov - 2018 Set 1

78. Define quality and explain the factors that influence the quality of a product. [7M] Nov - 2018 Set 1

79. The following table gives the number of defects in a casting used for making crank case of diesel engine.

Casting No.	1	2	3	4	5	6	7	8	9	10
No. of Defects	15	11	25	10	12	20	15	10	17	13

Construct an appropriate control chart with the control limits and comment on the process.

[7M] Nov - 2018 Set 1

80. Describe the general structure for double sampling plan. What are their advantages and disadvantages?

[15M] Nov - 2018 Set 1

UNIT-5

HUMAN RESOURCE MANAGEMENT/RESOURCE MANAGEMENT

SYLLABUS:

RESOURCE MANAGEMENT: Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, merit rating, quantitative methods, wage incentive plans, types.

INTRODUCTION

Human beings are social beings and hardly ever live and work in isolation. We always plan, develop and manage our relations both consciously and unconsciously. The relations are the outcome of our actions and depend to a great extent upon our ability to manage our actions. From childhood each and every individual acquire knowledge and experience on understanding others and how to behave in each and every situations in life. Later we carry forward this learning and understanding in carrying and managing relations at our workplace. The whole context of Human Resource Management revolves around this core matter of managing relations at work place.

Since mid-1980's Human Resource Management (HRM) has gained acceptance in both academic and commercial circle. HRM is a multidisciplinary organizational function that draws theories and ideas from various fields such as management, psychology, sociology and economics.

There is no best way to manage people and no manager has formulated how people can be managed effectively, because people are complex beings with complex needs. Effective HRM depends very much on the causes and conditions that an organizational setting would provide. Any Organization has three basic components, People, Purpose, and Structure.

In 1994, a noted leader in the human resources (HR) field made the following observation: Yesterday, the company with the access most to the capital or the latest technology had the best competitive advantage;

Today, companies that offer products with the highest quality are the ones with a leg up on the competition; but the only thing that will uphold a company's advantage tomorrow is the calibre of people in the organization. That predicted future is today's reality. Most managers in public- and private sector firms of all sizes would agree that people truly are the organization's most important asset. Having competent staff on the payroll does not guarantee that a firm's human resources will be a source of competitive advantage. However in order to remain competitive, to grow, and diversify an organization must ensure that its employees are qualified, placed in appropriate positions, properly trained, managed effectively, and committed to the firm's success. The goal of HRM is to maximize employees' contributions in order to achieve optimal productivity and effectiveness, while simultaneously attaining individual objectives (such as

having a challenging job and obtaining recognition), and societal objectives (such as legal compliance and demonstrating social responsibility).

WHAT IS HUMAN RESOURCE MANAGEMENT?

HRM is the study of activities regarding people working in an organization. It is a managerial function that tries to match an organization's needs to the skills and abilities of its employees.

Definitions of HRM

Human resources management (HRM) is a management function concerned with hiring, motivating and maintaining people in an organization. It focuses on people in organizations. Human resource management is designing management systems to ensure that human talent is used effectively and efficiently to accomplish organizational goals.

HRM is the personnel function which is concerned with procurement, development, compensation, integration and maintenance of the personnel of an organization for the purpose of contributing towards the accomplishments of the organization's objectives. Therefore, personnel management is the planning, organizing, directing, and controlling of the performance of those operative functions (Edward B. Philippo)

According to the Invancevich and Glueck, "HRM is concerned with the most effective use of people to achieve organizational and individual goals. It is the way of managing people at work, so that they give their best to the organization".

According to Dessler (2008) the policies and practices involved in carrying out the "people" or human resource aspects of a management position, including recruiting, screening, training, rewarding, and appraising comprises of HRM.

Generally HRM refers to the management of people in organizations. It comprises of the activities, policies, and practices involved in obtaining, developing, utilizing, evaluating, maintaining, and retaining the appropriate number and skill mix of employees to accomplish the organization's objectives. The goal of HRM is to maximize employees' contributions in order to achieve optimal productivity and effectiveness, while simultaneously attaining individual objectives (such as having a challenging job and obtaining recognition), and societal objectives (such as legal compliance and demonstrating social responsibility).

In short Human Resource Management (HRM) can be defined as the art of procuring, developing and maintaining competent workforce to achieve the goals of an organization in an effective and efficient manner

NATURE OF HRM

HRM is a management function that helps manager's to recruit, select, train and develop members for an organization. HRM is concerned with people's dimension in organizations.

The following constitute the core of HRM

1. HRM Involves the Application of Management Functions and Principles. The functions and principles are applied to acquiring, developing, maintaining and providing remuneration to employees in organization.
2. Decision Relating to Employees must be integrated. Decisions on different aspects of employees must be consistent with other human resource (HR) decisions.
3. Decisions Made Influence the Effectiveness of an Organization. Effectiveness of an organization will result in betterment of services to customers in the form of high quality products supplied at reasonable costs.
4. HRM Functions are not confined to Business Establishments Only but applicable to non-business organizations such as education, health care, recreation and like.

HRM refers to a set of programmes, functions and activities designed and carried out in order to maximize both employee as well as organizational effectiveness.

SCOPE OF HRM :

The scope of HRM is indeed vast. All major activities in the working life of a worker – from the time of his or her entry into an organization until he or she leaves the organizations comes under the purview of HRM. The major HRM activities include HR planning, job analysis, job design, employee hiring, employee and executive remuneration, employee motivation, employee maintenance, industrial relations and prospects of HRM.

The scope of Human Resources Management extends to:

- All the decisions, strategies, factors, principles, operations, practices, functions, activities and methods related to the management of people as employees in any type of organization.
- All the dimensions related to people in their employment relationships, and all the dynamics that flow from it.

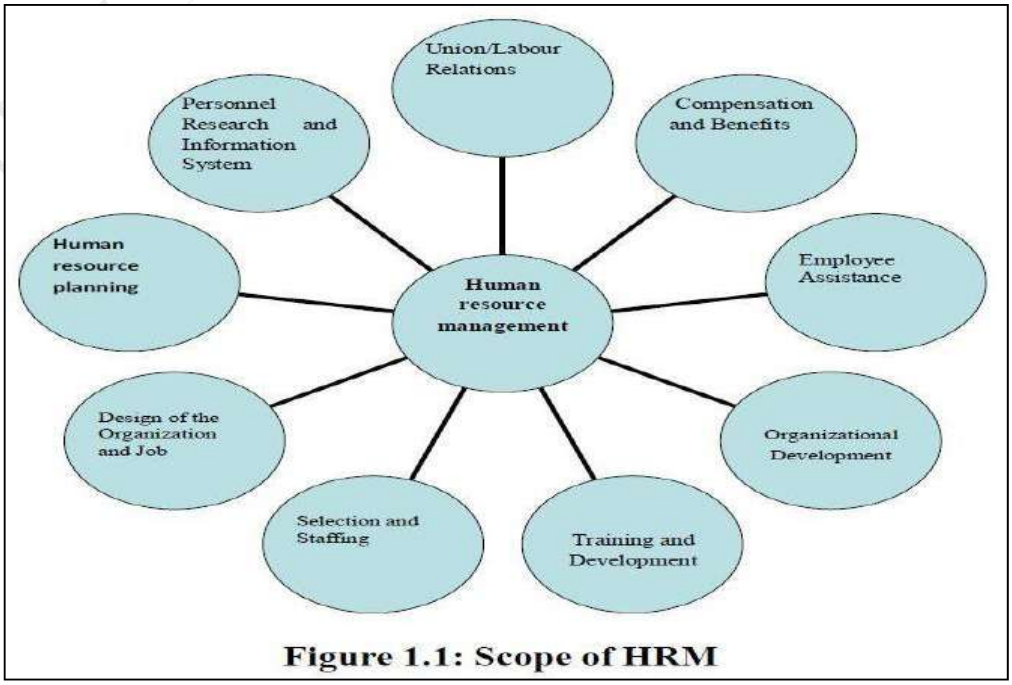


Figure 1.1: Scope of HRM

The scope of HRM is really vast. All major activities n the working life of a worker – from the time of his or her entry into an organization until he or she leaves it comes under the purview of HRM. American Society for Training and Development (ASTD) conducted fairly an exhaustive study in this field and identified nine broad areas of activities of HRM.

These are given below:

1. Human Resource Planning
2. Design of the Organization and Job
3. Selection and Staffing
4. Training and Development
5. Organizational Development
6. Compensation and Benefits
7. Employee Assistance
8. Union/Labour Relations
9. Personnel Research and Information System

a) Human Resource Planning: The objective of HR Planning is to ensure that the organization has the right types of persons at the right time at the right place. It prepares human resources inventory with a view to assess present and future needs, availability and possible shortages in human resource. Thereupon, HR Planning forecast demand and supplies and identify sources of selection. HR

Planning develops strategies both long-term and short-term, to meet the man-power requirement.

b) Design of Organization and Job: This is the task of laying down organization structure, authority, relationship and responsibilities. This will also mean definition of work contents for each position in the organization. This is done by "job description". Another important step is "Job specification".

Job specification identifies the attributes of persons who will be most suitable for each job which is defined by job description.

c) Selection and Staffing: This is the process of recruitment and selection of staff. This involves matching people and their expectations with which the job specifications and career path available within the organization.

d) Training and Development: This involves an organized attempt to find out training needs of the individuals to meet the knowledge and skill which is needed not only to perform current job but also to fulfil the future needs of the organization.

e) Organizational Development: This is an important aspect whereby "Synergetic effect" is generated in an organization i.e. healthy interpersonal and inter-group relationship within the organization.

f) Compensation and Benefits: This is the area of wages and salaries administration where wages and compensations are fixed scientifically to meet fairness and equity criteria. In addition labour welfare measures are involved which include benefits and services.

g) Employee Assistance: Each employee is unique in character, personality, expectation and temperament. By and large each one of them faces problems every day. Some are personal some are official. In their case he or she remains worried. Such worries must be removed to make him or her more productive and happy.

h) Union-Labour Relations: Healthy Industrial and Labour relations are very important for enhancing peace and productivity in an organization. This is one of the areas of HRM.

i) **Personnel Research and Information System:** Knowledge on behavioural science and industrial psychology throws better insight into the workers expectations, aspirations and behaviour. Advancement of technology of product and production methods have created working environment which are much different from the past. Globalization of economy has increased competition many fold. Science of ergonomics gives better ideas of doing a work more conveniently by an employee. Thus, continuous research in HR areas is an unavoidable requirement. It must also take special care for improving exchange of information through effective communication systems on a continuous basis especially on moral and motivation.

HRM is a broad concept; personnel management (PM) and Human resource development (HRD) are a part of HRM.

OBJECTIVES OF HRM:

The primary objective of HRM is to ensure the availability of competent and willing workforce to an organization. The specific objectives include the following:

1) Human capital: assisting the organization in obtaining the right number and types of employees to fulfill its strategic and operational goals
2) Developing organizational climate: helping to create a climate in which employees are encouraged to develop and utilize their skills to the fullest and to employ the skills and abilities of the workforce efficiently
3) Helping to maintain performance standards and increase productivity through effective job design; providing adequate orientation, training and development; providing performance-related feedback; and ensuring effective two-way communication.
4) Helping to establish and maintain a harmonious employer/employee relationship
5) Helping to create and maintain a safe and healthy work environment.
6) Developing programs to meet the economic, psychological, and social needs of the employees and helping the organization to retain the productive employees
7) Ensuring that the organization is in compliance with provincial/territorial and federal laws affecting the workplace (such as human rights, employment equity, occupational health and safety, employment standards, and labour relations legislation). To help the organization to reach its goals
8) To provide organization with well-trained and well-motivated employees.
9) To increase the employees satisfaction and self-actualization.
10) To develop and maintain the quality of work life.
11) To communicate HR policies to all employees.
12) To help maintain ethical polices and behavior.

The above stated HRM objectives can be summarized under four specific objectives: societal, organizational, and functional and personnel.

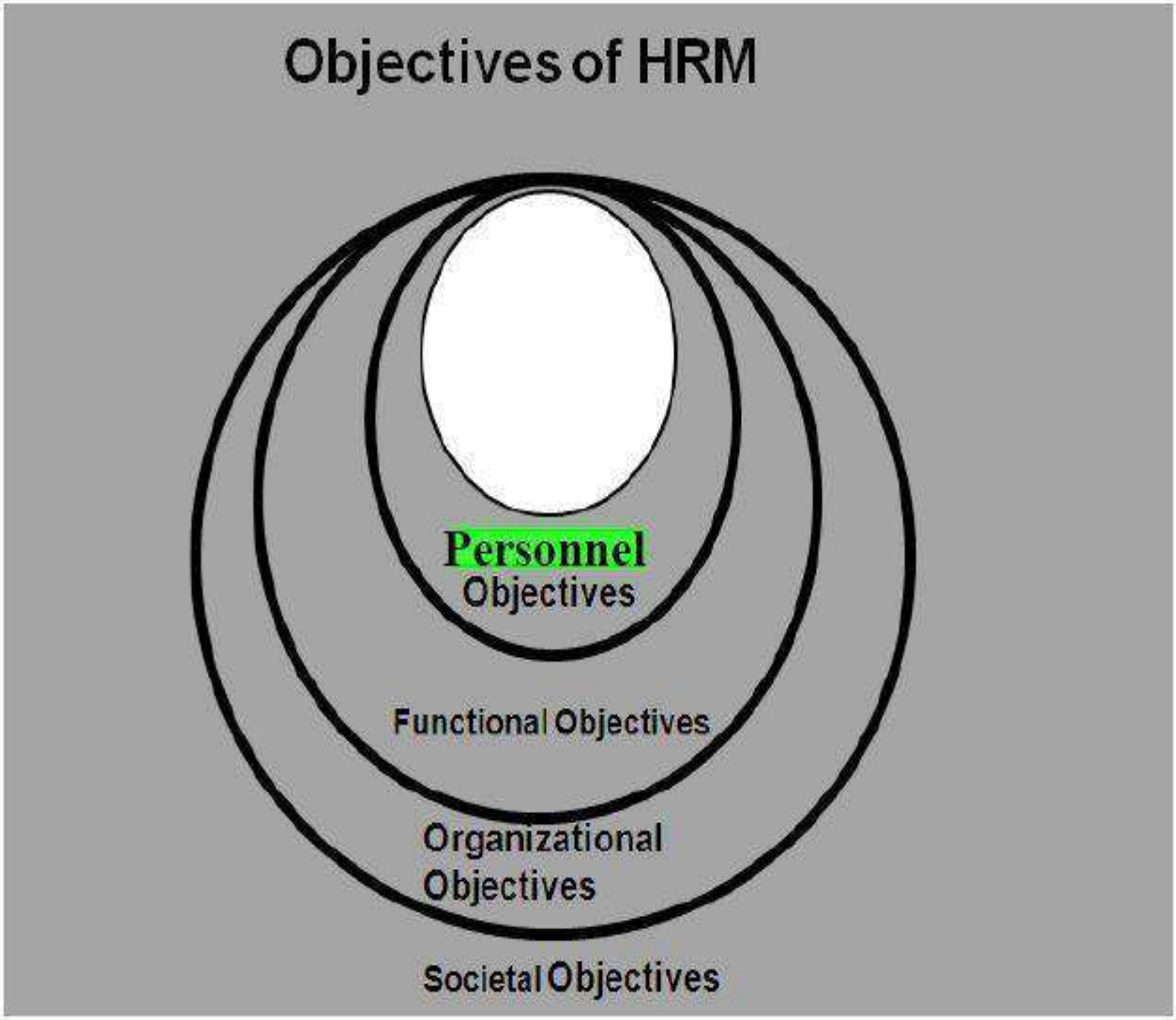


Figure 1.2: Objectives of HRM

1) **Societal Objectives**: seek to ensure that the organization becomes socially responsible to the needs and challenges of the society while minimizing the negative impact of such demands upon the organization. The failure of the organizations to use their resources for the society's benefit in ethical ways may lead to restriction.
2) **Organizational Objectives**: it recognizes the role of HRM in bringing about organizational effectiveness. It makes sure that HRM is not a standalone department, but rather a means to assist the organization with its primary objectives. The HR department exists to serve the rest of the organization.
3) **Functional Objectives:** is to maintain the department's contribution at a level appropriate to the organization's needs. Human resources are to be adjusted to suit the organization's demands. The department's value should not become too expensive at the cost of the organization it serves.
4) **Personnel Objectives:** it is to assist employees in achieving their personal goals, at least as far as these goals enhance the individual's contribution to the organization. Personal objectives of employees must be met if they are to be maintained, retained and motivated. Otherwise employee performance and satisfaction may decline giving rise to employee turnover.

Table 1.1 HRM Objectives and Functions

S.No.	HRM Objectives	Supporting Functions
1.	Societal Objectives	Legal compliance Benefits Union- management relations
2.	Organizational Objectives	Human Resource Planning Employee relations Selection Training and development Appraisal Placement Assessment
3.	Functional Objectives	Appraisal Placement Assessment
4.	Personal Objectives	Training and development Appraisal Placement Compensation Assessment

FUNCTIONS OF HRM:

Human Resources management has an important role to play in equipping organizations to meet the challenges of an expanding and increasingly competitive sector. Increase in staff numbers, contractual diversification and changes in demographic profile which compel the HR managers to reconfigure the role and significance of human resources management. The functions are responsive to current staffing needs, but can be proactive in reshaping organizational objectives. All the functions of HRM are correlated with the core objectives of HRM (Table 1.1). For example personal objectives is sought to be realized through functions like remuneration, assessment etc.

HR management can be thought of as seven interlinked functions taking place within organizations, as depicted in Figure 1.3 Additionally, external forces—legal, economic, technological, global, environmental, cultural/geographic, political, and social—significantly affect how HR functions are designed, managed, and changed. The functions can be grouped as follows:

Strategic HR Management: As a part of maintaining organizational competitiveness, strategic planning for HR effectiveness can be increased through the use of HR metrics and HR technology. Human resource planning (HRP) function determine the number and type of employees needed to accomplish organizational

goals. HRP includes creating venture teams with a balanced skill-mix, recruiting the right people, and voluntary team assignment. This function analyses and determines personnel needs in order to create effective innovation teams. The basic HRP strategy is staffing and employee development.

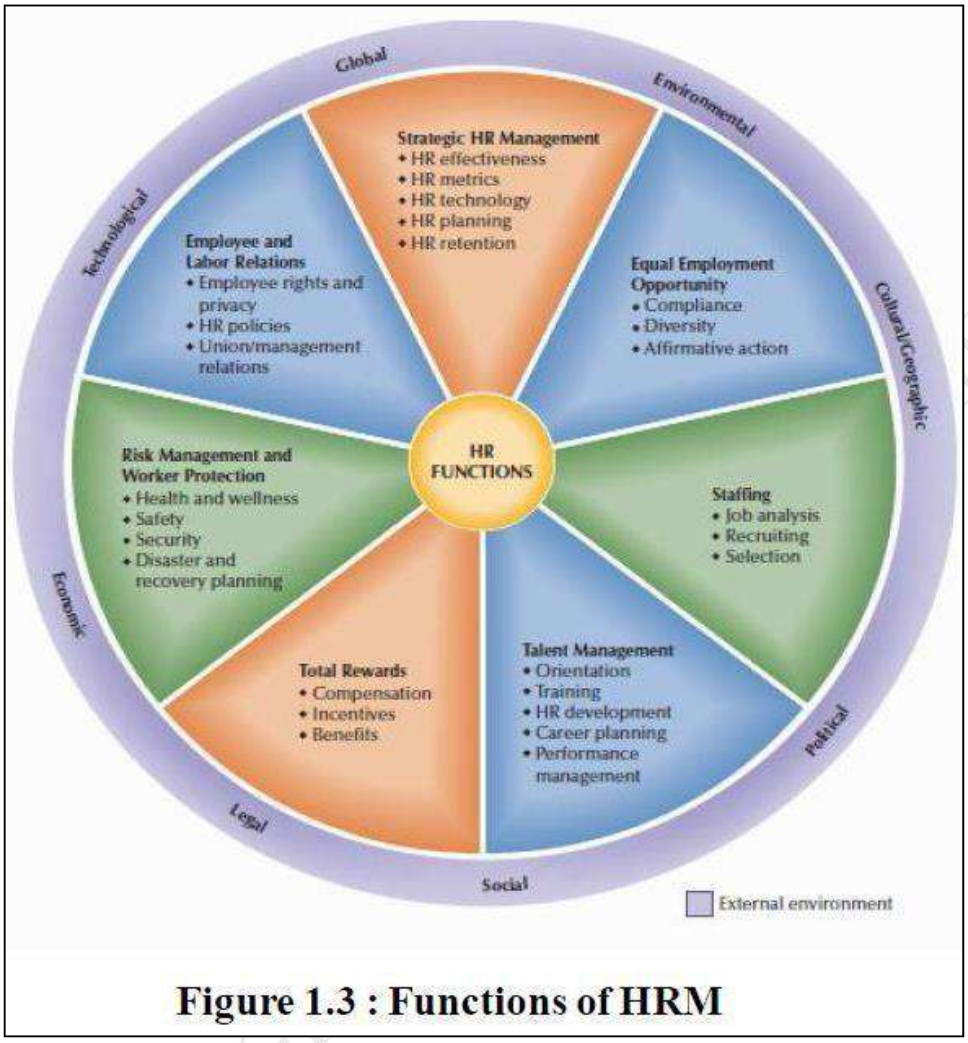


Figure 1.3 : Functions of HRM

Equal Employment Opportunity: Compliance with equal employment opportunity (EEO) laws and regulations affects all other HR activities.

Staffing: The aim of staffing is to provide a sufficient supply of qualified individuals to fill jobs in an organization. Job analysis, recruitment and selection are the main functions under staffing.

Workers job design and job analysis laid the foundation for staffing by identifying what diverse people do in their jobs and how they are affected by them.

Job analysis is the process of describing the nature of a job and specifying the human requirements such as knowledge, skills, and experience needed to perform the job. The end result of job analysis is job description. Job description spells out work duties and activities of employees.

Through HR planning, managers anticipate the future supply of and demand for employees and the nature of workforce issues, including the retention of employees. So HRP precedes the actual selection of people for organization. These factors are used when recruiting applicants for job openings. The selection process is concerned with choosing qualified individuals to fill those jobs.

In the selection function, the most qualified applicants are selected for hiring from among the applicants based on the extent to which their abilities and skills are matching with the job.

Talent Management and Development: Beginning with the orientation of new employees, talent management and development includes different types of training. Orientation is the first step towards helping a new employee to adjust himself to the new job and the employer. It is a method to acquaint new employees with particular aspects of their new job, including pay and benefit programmes, working hours and company rules and expectations.

Training and Development programs provide useful means of assuring that the employees are capable of performing their jobs at acceptable levels and also more than that. All the organizations provide training for new and in experienced employee. In addition, organization often provide both on the job and off the job training programmes for those employees whose jobs are undergoing change.

Likewise, HR development and succession planning of employees and managers is necessary to prepare for future challenges. Career planning has developed as result of the desire of many employees to grow in their jobs and to advance in their career. Career planning activities include assessing an individual employee's potential for growth and advancement in the organization.

Performance appraisal includes encouraging risk taking, demanding innovation, generating or adopting new tasks, peer evaluation, frequent evaluations, and auditing innovation processes.

This function monitors employee performance to ensure that it is at acceptable levels. This strategy appraises individual and team performance so that there is a link between individual innovativeness and company profitability. Which tasks should be appraised and who should assess employees' performance are also taken into account.

Total Rewards: Compensation in the form of pay, incentives and benefits are the rewards given to the employees for performing organizational work. Compensation management is the method for determining how much employees should be paid for performing certain jobs. Compensation affects staffing in that people are generally attracted to organizations offering a higher level of pay in exchange for the work performed. To be competitive, employers develop and refine their basic compensation systems and may use variable pay programs such as incentive rewards, promotion from within the team, recognition rewards, balancing team and individual rewards etc. This function uses rewards to motivate personnel to achieve an organization's goals of productivity, innovation and profitability. Compensation is also related to employee development in that it provides an important incentive in motivating employees to higher levels of job performance to higher paying jobs in the organization.

Benefits are another form of compensation to employees other than direct pay for the work performed. Benefits include both legally required items and those offered at employer's discretion. Benefits are primarily related to the area of employee maintenance as they provide for many basic employee needs.

Risk Management and Worker Protection: HRM addresses various workplace risks to ensure protection of workers by meeting legal requirements and being more responsive to concerns for workplace health and safety along with disaster and recovery planning.

Employee and Labor Relations: The relationship between managers and their employees must be handled legally and effectively. Employer and employee rights must be addressed. It is important to develop, communicate, and update HR policies and procedures so that managers and employees alike know what is expected. In some organizations, union/management relations must be addressed as well. The term labour relation refers to the interaction with employees who are represented by a trade union. Unions are organization of employees who join together to obtain more voice in decisions affecting wages, benefits, working conditions and other aspects of employment. With regard to labour relations the major function of HR personnel includes negotiating with the unions regarding wages, service conditions and resolving disputes and grievances.

FUNCTIONS OF HR MANAGER:

Procurement	Development	Motivation &Compensation	Maintenance	Integration
Job analysis	Training	Job design	Health & Safety	Grievance Redressal
Human Resource Planning	Executive Development	Work Scheduling	Employee Welfare	Discipline
Recruitment	Career Planning & Development	Motivation	Social Security	Teams & Team Work
Selection	Human Resource Development	Job Evaluation		Collective Bargaining
Placement		Performance Appraisal		Employee Participation &Empowerment
Induction & Orientation		Compensation Administration		Trade Unions & Employees Associations
Internal Mobility		Incentives & Benefits		Industrial Relations.

It has two types

MANAGERIAL FUNCTIONS

1) Planning
2) Organizing
3) Staffing
4) Directing
5) Controlling

OPERATIVE FUNCTIONS

The operative functions of HRM are related to specific activities of personnel management, viz., employment, development, compensation, organizational and industrial relations. These functions are to be performed in conjunction with managerial functions

- **Procurement function:** The first operative function of personnel management is procurement. It is concerned with procuring and employing people who possess necessary skills, knowledge and aptitude. Under its purview you have job analysis, man power planning, recruitment, selection, placement, induction, and internal mobility.
- **Job analysis:** It is the process of collecting information relating to the operation and responsibilities pertaining to a specific job.
- **Human Resource Planning:** It is a process of determining and assuring that the organization will have an adequate number of qualified persons, available at proper times, performing jobs which would meet their needs and provide satisfaction for the individuals involved.
- **Recruitment:** It is the process of searching for prospective employees and stimulating them to apply for jobs in the organization. Selection: It is the process of ascertaining qualification, experience, skill and knowledge of an applicant with a view to applicant with a view to appraising his/her suitability to the job in question.
- **Selection:** It is the process of ascertaining qualifications, experience, skill and knowledge of an applicant with a view to appraising his/her suitability to the job in question.
- **Placement:** It is the process that ensures 360 degrees fit, matching the employees qualification, experience, skills and interest with the job on offer. It is the personnel managers' responsibility to position the right candidate at the right level.
- **Induction and Orientation:** Induction and orientation are the techniques by which a new employee is rehabilitated in his surroundings and introduces to the practices, policies, and people.
- **Internal Mobility:** The movement of employees form one job to another through transfers and promotions is called internal mobility. Some employees leave an organization due to various reasons leading to resignation, retirement and even termination. These movement are known as external mobility.
- **Development:** It is the process of improving, moulding, changing and developing the skills, Knowledge, creative ability, attitude, values and commitment based on present and future requirement both at the individuals and organization's level. This function includes.
- **Training:** Training is a continuous process by which employees learn skills, knowledge, abilities and attitudes to further organizational and personnel goals.

- **Executive development:** It is a systematic process of developing managerial skills and capabilities through appropriate programmers.
- **Career Planning and Development:** It is the planning of one's career and implementation of career plans by means of education, training, job search and acquisition of work experiences. It includes succession planning which implies identifying developing and tracking key individuals for executive positions.
- **Human Resource Development:** HRD aims at developing the total organization. It creates a climate that enables every employee to develop and use his capabilities in order to further oth individual and organization goals.
- **Motivation and Compensation:** It is a process which inspires to give their best to the organization through the use of intrinsic (achievement, recognition, responsibility) and extrinsic (job design, work scheduling, appraisal based incentives) rewards.
- **Job design:** Organizing tasks and responsibilities towards having a productive unit of work is call job design. The main purpose of job design is to integrate the needs of employees to suit the requirement of an organization.
- **Work scheduling:** Organizations must realize the importance of scheduling work to motivate employees through job enrichment, shorter work, week's flexi-time, and work sharing work assignments. Work scheduling is an attempt to structure work, incorporating the physical, physiological and behavioural aspects of work.
- **Motivation:** Combine forces that allow people to behave in certain ways is an integral aspect of motivation. Managers generally try to motivate people through properly administrated rewards (monetary and non-monetary).
- **Job evaluation:** Organizations formally determine the value of jobs through the process of job evaluation. Job evaluation is a systematic process of determining the relative worth of jobs in order to establish which jobs should be paid more than others within the organization.
- **Performance appraisal:** After an employee has be selected for job has been trained to do it and has worked on it for a period of time, his performance should be evaluated. It is a process of deciding how many employed to do their jobs. It is a method of evaluating the behaviour of employees at the work place and normally includes both the quantitative and qualitative aspects of job performance.
- **Compensation administration:** Compensation administration is the process of dividing how many an employees should be paid. The important goals are design a low-cost pay plan that will attract, motivate and retain competent employees-which is also perceives to be fair by these employees.

- **Incentives and benefits:** In addition to basic wage structure, most organizations now a days offer incentive compensation based on actual performance. Unlike incentives, benefits and services are offered to all employees as required by law including social security, insurance, workmen's compensation, welfare amenities
- **Maintenance:** It aims at protecting and preserving the physical and psychological health of employees through various welfare measures.
- **Health and safety:** Managers at all levels are expected to know and enforce safety and health Standards throughout the organization. They must ensure a work environment that protects employees from physical hazards, unhealthy conditions and unsafe acts of other personnel.
- **Employee welfare:** It includes the services, amenities and facilities offered to employees within or outside the establishment for their physical, psychological and social well-being. Housing, transportation, education and recreation facilities are all includes in the employee welfare package.
- **Social security:** Management provide social security to their employees in addition to fringe benefits. It includes workman's compensation to those workers who are involved in accidents, maternity benefits to woman employees, sickness benefits and medical benefits, disablement benefits/allowances, dependent benefits and medical benefits, disablement benefits, retirement benefits like provident fund, pension gratuity.
- **Integration function:** This tries to integrate the goals of an organization with employee aspirations through various employee-oriented programs like readdressing, like redressing grievances promptly, instituting proper disciplinary measures, and empowering people to decide things independently encouraging a participative culture, offering constructive help to trade unions etc.
- **Grievance redressal:** A grievance is any factor involving wages, hours or conditions of employment that is used as a complaint against the employer. Constructive grievance handling depends first on the manager's ability to recognize, diagnose and correct the causes of potential employee dissatisfaction before it covers into a formal grievance.
- **Discipline:** It is the force that prompts an individual or a group to observe the rules, regulations and procedures, which are deemed necessary for the attainment of an objective.
- **Teams and teamwork:** self-managed teams have emerged as the most important formal groups in today's organizations. They enhance employee involvement and have the potential to create positive synergy by increasing worker interaction; they create camaraderie among team members. Teams have inherent strengths which ultimately lead to organizational success at various levels.
- **Collective bargaining:** It is a process of agreeing on a satisfactory labor contract between management and union. The contract contains agreements about the conditions of employment such as wages, hours, promotion and discipline; lay-off, benefits vacations rest pause and the grievance procedure.

- **Employee participation and empowerment:** Participation means sharing the decision-making power with the lower ranks of an organization in an appropriate manner. When workers participate in organizations decisions they are able to see big picture clearly and also how their actions would impact the overall growth of the company. They can offer the feedback immediately based on their experiences and improve the quality of decisions.
- **Trade unions and employees association:** Trade union is an association either of employees or employers or independent workers. It is a relatively permanent a body formed by workers with the objective of countering exploitation and harassment. It strives towards providing economic and social benefits to the labor community.
- **Industrial Relations:** Harmonious industrial relations between labor and management are essential to achieve industrial growth and higher productivity.

ROLE OF HRM:

The role of HRM is to plan, develop and administer policies and programs designed to make optimum use of an organizations human resources. It is that part of management which is concerned with the people at work and with their relationship within enterprises. Its objectives are:

(a) Effective utilization of human resources,
(b) Desirable working relationships among all members of the organizations, and
(c) Maximum individual development. Human resources function as primarily administrative and professional. HR staff focused on administering benefits and other payroll and operational functions and didn't think of themselves as playing a part in the firm's overall strategy.

HR professionals have an all-encompassing role. They are required to have a thorough knowledge of the organization and its intricacies and complexities. The ultimate goal of every HR person should be to develop a linkage between the employee and organization because employee's commitment to the organization is crucial. The first and foremost role of HR personnel is to impart continuous education to the employees about the changes and challenges facing the country in general and their organization in particular. The employees should know about the balance sheet of the company, sales progress, and diversification of plans, share price movements, turnover and other details about the company. The HR professionals should impart such knowledge to all employees through small booklets, video films and lectures.

The primary responsibilities of Human Resource managers are:

1) To develop a thorough knowledge of corporate culture, plans and policies.
2) To act as an internal change agent and consultant
3) To initiate change and act as an expert and facilitator
4) To actively involved in company's strategy formulation

5) To keep communication line open between the HRD function and individuals and groups both within and outside the organization\
6) To identify and evolve HRD strategies in consonance with overall business strategy.
7) To facilitate the development of various organizational teams and their working relationship with other teams and individuals.
8) To try and relate people and work so that the organization objectives are achieved efficiently and effectively.
9) To diagnose problems and determine appropriate solution particularly in the human resource areas.
10) To provide co-ordination and support services for the delivery of HRD programmes and services
11) To evaluate the impact of an HRD intervention or to conduct research so as to identify, develop or test how HRD In general has improved individual and organizational performance.

Different management gurus have deliberated different roles for the HR manager based on the major responsibilities that they full fill in the organization. Few of the commonly accepted models are enumerated below.

Pat Mc Lagan has suggested nine roles that are played by HR practitioners

To bring the issues and trends concerning an organization's external and internal people to the attention of strategic decision makers and to recommend long term strategies to support organizational excellence and endurance.

1) To design and prepare HR systems and actions for implementation so that they can produce maximum impact on organizational performance and development.
2) To facilitate the development and implementation of strategies for transforming one's own organization by pursuing values and visions.
3) To create a positive relationship with the customer's by providing them with the best services; to utilize the resources to the maximum and to create commitment among the people who help the organization to meet the customer's needs whether directly connected or indirectly connected to the organization.
4) To identify the learning needs hence to design and develop structured learning programs and materials to help accelerate learning for individuals and groups.
5) To enable the individuals and groups to work in new situations and to expend \and change their views so that people in power move from authoritarian to participative models of leadership.
6) To help employees to assess their competencies, values and goals so that they can identify, plan and implement development plans.
7) He also assists the individual employee to add values in the workplace and to focus on the interventions and interpersonal skills for helping people change and sustain change.
8) He assesses the HRD practices and programs and their impact and to communicate results so that the organization and its people accelerate their change and development.

According to Dave Ulrich HR play's four key roles.

1. **Strategic Partner Role**-turning strategy into results by building organizations that create value;
2. **Change Agent Role**- making change happen, and in particular, help it happen fast
3. **Employees Champion Role**—managing the talent or the intellectual capital within a firm
4. **Administrative Role**—trying to get things to happen better, faster and cheaper.

The role HR in organizations has undergone an extensive change and many organizations have gradually oriented themselves from the traditional personnel management to a human resources management approach.

The basic approach of HRM is to perceive the organization as a whole. Its emphasis is not only on production and productivity but also on the quality of life. It seeks to achieve the paramount development of human resources and the utmost possible socio-economic development.

CURRENT CLASSIFICATION OF HR ROLES:

According to R.L Mathis and J. H. Jackson (2010) several roles can be fulfilled by HR management. The nature and extent of these roles depend on both what upper management wants HR management to do and what competencies the HR staff have demonstrated. Three roles are typically identified for HR. The focus of each of them, as shown in Figure 1.is elaborated below:

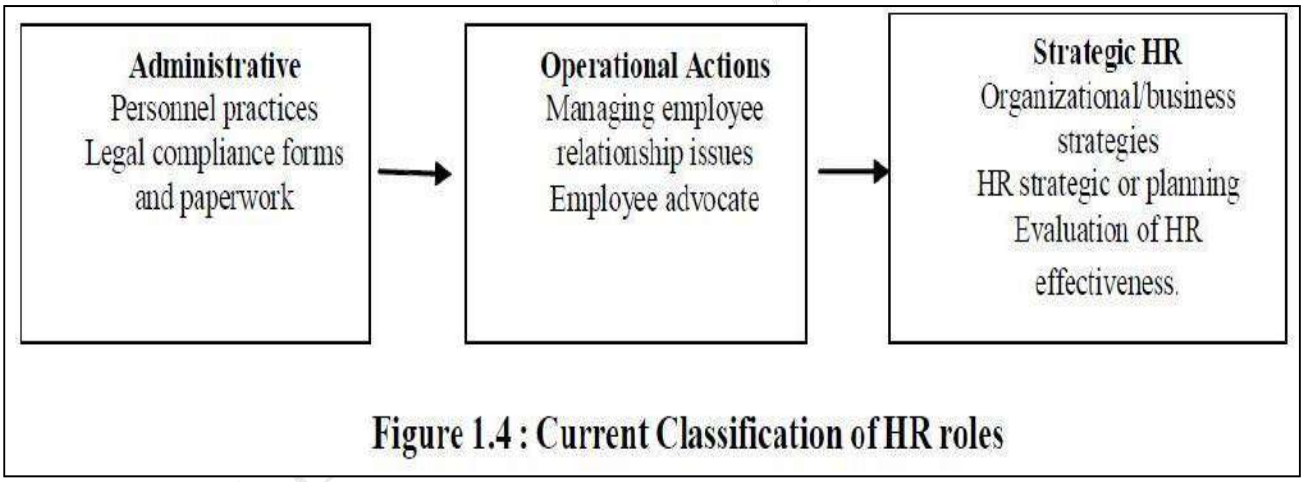


Figure 1.4 : Current Classification of HR roles

1. **Administrative Role of HR:** The administrative role of HR management has been heavily oriented to administration and recordkeeping including essential legal paperwork and policy implementation. Major changes have happened in the administrative role of HR during the recent years. Two major shifts driving the transformation of the administrative role are: Greater use of technology and Outsourcing.

   Technology has been widely used to improve the administrative efficiency of HR and the responsiveness of HR to employees and managers, more HR functions are becoming available electronically or are being done on the Internet using Web-based technology. Technology is being used in most HR activities, from employment applications and employee benefits enrolment's to e-learning using Internet-based resources. Increasingly, many HR administrative functions are being outsourced to vendors. This outsourcing of HR administrative activities has grown dramatically in HR areas such as employee assistance (counselling), retirement planning, benefits administration, payroll services, and outplacement services.

2. **Operational and Employee Advocate Role for HR:** HR managers manage most HR activities in line with the strategies and operations that have been identified by management and serves as employee "champion" for employee issues and concerns.

   HR often has been viewed as the "employee advocate" in organizations. They act as the voice for employee concerns, and spend considerable time on HR "crisis management," dealing with employee problems that are both work-related and not work-related. Employee advocacy helps to ensure fair and equitable treatment for employees regardless of personal background or circumstances.

   Sometimes the HR's advocate role may create conflict with operating managers. However, without the HR advocate role, employers could face even more lawsuits and regulatory complaints than they do now. The operational role requires HR professionals to cooperate with various departmental and operating managers and supervisors in order to identify and implement needed programs and policies in the organization. Operational activities are tactical in nature. Compliance with equal employment opportunity and other laws is ensured, employment applications are processed, current openings are filled through interviews, supervisors are trained, safety problems are resolved, and wage and benefit questions are answered. For carrying out these activities HR manager matches HR activities with the strategies of the organization.

3. **Strategic Role for HR:** The administrative role traditionally has been the dominant role for HR. However, as Figure 1.4 indicates that a broader transformation in HR is needed so that significantly less HR time and fewer HR staffs are used just for clerical work.

   Differences between the operational and strategic roles exist in a number of HR areas. The strategic HR role means that HR professionals are proactive in addressing business realities and focusing on future business needs, such as strategic planning, compensation strategies, the performance of HR, and measuring its results. However, in some organizations, HR often does not play a key role in formulating the strategies for the organization as a whole; instead it merely carries them out through HR activities.

   Many executives, managers, and HR professionals are increasingly seeing the need for HR management to become a greater strategic contributor to the "business" success of organizations. HR should be responsible for knowing what the true cost of human capital is for an employer. For example, it may cost two times key employees' annual salaries to replace them if they leave. Turnover can be controlled though HR activities, and if it is successful in saving the company money with good retention and talent management strategies, those may be important contributions to the bottom line of organizational performance.

The role of HR as a *strategic business partner* is often described as "having a seat at the table," and contributing to the strategic directions and success of the organization. That means HR is involved in *devising* strategy in addition to *implementing* strategy. Part of HR's contribution is to have financial expertise and to produce financial results, not just to boost employee morale or administrative efficiencies.

Therefore, a significant concern for chief financial officers (CFOs) is whether HR executives are equipped to help them to plan and meet financial requirements.

However, even though this strategic role of HR is recognized, many organizations still need to make significant progress toward fulfilling it. Some examples of areas where strategic contributions can be made by HR are:

- ☞ Evaluating mergers and acquisitions for organizational "compatibility," structural changes, and staffing needs.
- ☞ Conducting workforce planning to anticipate the retirement of employees at all levels and identify workforce expansion in organizational strategic plans
- ☞ Leading site selection efforts for new facilities or transferring operations to international outsourcing.
- ☞ Locations based on workforce needs.
- ☞ Instituting HR management systems to reduce administrative time, equipment, and staff by using HR technology.
- ☞ Working with executives to develop a revised sales.
- ☞ Compensation and incentives plan as new products.

It is the era when for the competitive triumph of the organization there is a need to involve HRM significantly in an integrated manner, which demands such capabilities from the HR specialists.

The role of HR shifted from a facilitator to a functional peer with competencies in other functions, and is acknowledged as an equal partner by others. The HR is motivated to contribute to organizational objectives of profitability and customer satisfaction, and is seen as a vehicle for realization of quality development.

The department has a responsibility for monitoring employee satisfaction, since it is seen as substitute to customer satisfaction.

According to McKinsey's 7-S framework model HR plays the role of a catalyst for the organization.

According to this framework, effective organizational change is a complex relationship between seven S's. HRM is a total matching process between the three Hard S's (Strategy, Structure and Systems) and the four Soft S's (Style, Staff, Skills and Super-ordinate Goals). Clearly, all the S's have to complement each other and have to be aligned towards a single corporate vision for the organization to be effective. It has to be realized that most of the S's are determined directly or indirectly by the way Human Resources are managed, and therefore, HRM must be a part of the total business strategy.

COMPONENTS OR ELEMENTS OF HUMAN RESOURCES MANAGEMENT:

Human resource management is a process which involves around four basic functions- acquisition, development, motivation and maintenance of human resources. These basic elements are the key steps for achieving organizational goals. The basic influencing factor of these components is organizational goal

because such activities are to be performed within the given constraints in order to accomplish the task. These four elements or factors of HRM can be described as follows:

1. **Acquisition**: Acquisition function is concerned with recruitment and selection of manpower requirement for an organization. It ensures that the company has the right number of people at the right place and at the right time who are capable to complete required work. It is the starting point of human resource management function. Acquisition is primarily concerned with planning, recruitment, selection and socialization of employees. It selects and socializes the competent employees who have adopted the organization's culture.
2. **Development**: Development phase begins after the socialization of newly appointed employees in an organization. It is concerned with imparting knowledge and skill to perform the task properly. Moreover, it is an attempt to improve employee performance by imparting knowledge, changing attitudes and improving skills. It can be done through teaching, coaching, class-room courses, assignments, professional programs and so on. The ultimate goal of employee development is of course to enhance the future performance of the organization by the efficient employees. The development of employees is not only for newly appointed employees, it is also for existing employees to develop them according to change in internal and external environment.
3. **Motivation**: Only training and development do not inspire employees to do better work. For this, they should be motivated. Here motivation means an activity which induces and inspires people to perform well in actual work floor. Motivation includes job specification, performance evaluation, reward and punishment, work performance, compensation management, discipline and so on. It is important for better work performance because high performance depends on both ability and motivation.
4. **Maintenance**: Maintenance is the last components of human resource management. it is concerned with the process of retaining the employees in the organization. This contributes towards keeping the employees who can do extremely better for the organization. It creates such a homely and friendly environment for those high performers, and make them to remain in the same organization for a longer period of time. This requires that the organization should provide additional facilities, safe working conditions, friendly work environment, and satisfactory labor relations. If these activities are performed in right manner, we can expect to have capable and competent employees in the organization. These employees are committed to the organizational objectives and are satisfied with their jobs.

HUMAN RESOURCE INTRODUCTION:

Among various factors of production, which are used in organization, human resource is the most important. This is because the efficient use of physical resources (i.e. land, machinery, materials) ultimately depends on human factor is out to good use on various operations. The most efficient machinery in the world will not produce at an optimum level unless the people who operate the machinery know how to make it perform at its best and most importantly, are motivated to make their equipment produce efficiently.

HRM means to Select, Develop, Motivate and Maintain human resources, in the organization. It first selects the right human resources or staff (i.e. managers and employees). It trains and develops them. It motivates them by giving them recognition and rewards. It also provides them with the best working conditions

DEFINITIONS:

"The Process of analysing and managing organizations human resources needs to ensure satisfaction of its strategic objectives"-Management **–Hellriegel/Slocum**

"The policies and practices involved in carrying out the 'people' or human resources aspects of a management position, including recruiting, screening, training and appraising."**--Human resource management –GrayDessler.**

Human Resource Management (HRM) is the function within an organization that focuses on recruitment of, management of, and providing direction for the people who work in the organization.

HUMAN RESOURCE DEVELOPMENT (HRD) DEFINITION:

According to American Society for Training and Development (ASTD),

"HRD is the integrated use of:-

- Training and development,
- Organizational development, and
- Career development to improve individual, group and organizational effectiveness."
- The part of human resource management that specifically deals with training and development of the employees.

Human resource development includes training an individual after he/she is first hired, providing opportunities to learn new skills, distributing resources that are beneficial for the employee's tasks, and any other developmental activities.

Human Resource Development (HRD) is the framework for helping employees develops their personal and organizational skills, knowledge, and abilities. Human Resource Development includes such opportunities as employee training, employee career development, performance management and development, coaching, mentoring, succession planning, key employee identification, tuition assistance, and organization development.

PERSONAL MANAGEMENT AND INDUSTRIAL RELATIONS (PMIR):

There is no standard definition of the term 'personnel management'. Different writers have given different definitions of the term.

Personnel management can be defined as obtaining, using and maintaining a satisfied workforce. It isa significant part of management concerned with employees at work and with their relationship within the organization.

According to Flippo, "Personnel management is the planning, organizing, compensation, integration and maintenance of people for the purpose of contributing to organizational, individual and societal goals."

According to Brech, "Personnel Management is that part which is primarily concerned with human resource of organization."

DEFINITIONS:

- "The personnel function is concerned with the procurement, development, compensation, integration, and maintenance of the personnel of an organization for the purpose of contributing toward the accomplishment of that organization's major goals or objectives. Therefore, personnel management is the planning, organising, directing, and controlling of the performance of those operative functions." — Edwin B. Flippo, Principles of Personnel Management.
- "Personnel management is that field of management which has to do with planning, organising, and controlling various operative activities of procuring, developing, maintaining and utilizing a labour force in order that the objectives and interest for which the company is established are attained as effectively and economically as possible and the objectives and interest of all levels of personnel and community are served to the highest degree." — M. J. Jucius, Personnel Management.
- "Manpower management effectively describes the processes of planning and directing the application, development, and utilisation of human resources in employment." — Dale Yodder, Personnel Management and Industrial Relations
- "Personnel Administration is a method of developing the potentialities of employees so that they get maximum satisfaction out of their work and give their best efforts to the organization." — Pigors and Myres, Personnel Administration
- "Personnel Management is that part of management process which is primarily concerned with the human constituents of an organization." — E.F.L. Brech (ed.) Principles and Practice of Management
- "Personnel management is that part of management function which is concerned with people at work and with their relationships within an enterprise. Its aim is to bring together and develop into an effective organization the men and women who make up an enterprise and, having regard to the well-being of an individual and of working groups, to enable to make their best contribution to its success". — The British Institute of Personnel Management
- "Personnel Management is that part of the management function which is primarily concerned with human relationships within an organization. Its objective is the maintenance of those relationships on a basis which, by consideration of the well-being of the individual, enables all those engaged in the undertaking to make their maximum personal contribution in the effective working of the undertaking." — Indian Institute of Personnel Management, Kolkata.

OBJECTIVES OF PERSONNEL MANAGEMENT:

These are classified into two:

a) General Objectives:

These reveal the basic philosophy of top management towards the labour force engaged on the work and its deep underlying conviction as to the importance of the people in the organization. The following are the most important objectives.

(i) Maximum individual development:

The employer should always be careful in developing the personality of each individual. Each individual differs in nature and therefore management should recognise their individual ability and make use of such ability in an effective and make use of such ability in an effective manner.

(ii) Desirable working relationship between employer and employees:

It is the main objective of personnel management to have a desirable working relationship between employee and employees so that they may co-operate the management.

(iii) Effective molding of human resources as contrasted with physical resources: Man is the only active factor of production, which engages the other factors of production to work.

b) Specific objectives: Following are some of the important activities:

(i) Selection of right type and number of persons required to the organization.

(ii) Proper orientation and introduction of new employees to the organization and their jobs.

(iii) Suitable training facilities for better job performance and to prepare the man to accept the challenge of higher job.

(iv) Provision of better working conditions and other facilities such as medical facilities.

(v) To give a good impression to the man who is leaving the organization.

(vi) Maintaining good relations with the employees.

FUNCTIONS OF PERSONNEL MANAGEMENT:

There are three categories of functions which the personnel manager is expected to perform. These are:

I. Managerial Functions,
II. Advisory Functions, and
III. Operative Functions.

(i) Managerial Functions: Personnel manager is a member of management. So he must perform the basic managerial functions of planning, organizing, staffing, directing and controlling in relation to his department.

(ii) Advisory Functions: Personnel Manager has specialized education and training in managing human relations He is an expert in his area and so can give advice on matters relating to human resources of the organization. He offers his advice to:

a) **Top Management:** Personnel manager advises the top management in formulation and evaluation of personnel Programmes, policies and procedures. He also gives advice for achieving and maintaining good human relations and high employee morale.

b) **Departmental Heads:** Personnel manager offers advice to the heads of various departments on matters such as manpower planning, job analysis and design, recruitment and selection, training performance appraisal, etc.

(iii) Operative Functions: The operative functions are those tasks or duties which are entrusted to the personnel department under general supervision of personnel manager. These are concerned with the employment, development, compensation integration and maintenance of personnel of the organization.

The personnel department performs the following operative functions:

(a) Employment: The first operative function of personnel department is the employment of proper kind and number of persons necessary to achieve the objectives of the organization. This involves recruitment, selection, placement, etc. of the personnel. Before these processes are performed, it is better to determine the manpower requirements both in terms of number and quality of the personnel.

Recruitment and selection cover the sources of supply of labour and the devices designed to select the right type of people for various jobs. Induction and placement of personnel for their better performance also come under the employment or procurement function.

(b) Training and Development: Training and development of personnel is a follow up of selection. It is a duty of management to train each employee properly to develop technical skills for the job for which he has been employed and also to develop him for the higher jobs in the organization.

Proper development of personnel is necessary to increase their skills in doing their jobs and in satisfying their growth need. For this purpose, the personnel department will devise appropriate training Programmes.

(c)Remuneration: This function is concerned with the determination of adequate and equitable remuneration of the employees in the organization for their contribution to the organization goals. The personnel can be compensated both in terms of monetary as well as non-monetary rewards.

(d) Working Conditions: Merely appointment and training of people is not sufficient, they must be provided with good working conditions so that they may like their work and work place and maintain their efficiency. Working conditions certainly influence the motivation and morale of the employees.

(e)Motivation: Employees work in the organization for the satisfaction of their needs. In many of the cases, it is found that they do not contribute towards the organization goals as much as they can.

This happens because employees are not adequately motivated. The personnel manager helps the various departmental managers to design a system of financial and non-financial rewards to motivate the employees.

(f) Personnel Records: Personnel department maintains the records of the employees working in the enterprise. It keeps full records of their training, achievements, transfer, promotion, etc. It also preserves many other records relating to the behaviour of personnel like absenteeism and labour turnover and the personnel Programmes and policies of the organization.

(g) Industrial Relations: These days, the responsibility of industrial relations is mainly discharged by the personnel managers. Personnel managers help in collective bargaining, joint consultation and settlement of disputes if they arise.

This is because personnel manager is in possession of full information relating to personnel and has the working knowledge of various labour enactments.

The personnel manager can do a great deal in maintaining industrial peace in the organizations as he is deeply associated with various committees on discipline, labour welfare, safety, grievance, etc.

He helps in laying down the grievance procedure to redress the grievances of the employees. He also gives authentic information to the trade union leaders and conveys their views on various labour problems to the top management.

Unions expect the personnel management to bargaining in good faith, establish equilibrium in power relations and implement agreements in latter and spirit. The government expects the personnel to implement its policies and meet statutory requirements.

The role of the personnel department should bear relationship with the expectations and demands placed on them by these various client groups. Satisfying the multiple objectives of these diverse groups productively is a major challenge facing personnel executives.

Meanings of some of the words used in this definition are explained below:

(i) Planning: Planning means determination of personnel programme in advance.

(ii) Organising: Organising means establishing an organization by designing the structure of relationships among job, personnel and other physical factors to attain the company objectives.

(iii) Directing: Directing means guiding the people to do the work effectively.

(iv) Controlling: Controlling means regulating the activities in accordance with the plan.

(v) Procurement: Procurement of labour means obtaining the proper kind of personnel in required quantity to achieve company goals.

(vi) Development: Development of labour means increasing the skill of employees through training.

(vii) Maintenance: Maintenance means improving the conditions (e.g., health, safety, welfare etc.,) and sustaining them.

Traditionally, personnel management system is concerned primarily with the five basic sub-systems, namely recruiting, placement training, compensation (pay, fringe benefits etc.) and maintenance.

Human Resource Management, as against these traditional functions should be considered as total system that interacts with the other major systems of the organization purchasing, production, finance, marketing etc. The primary object of the human resource management programme is to serve these major systems.

Forecasting and planning the personnel needs of the organization, maintaining an adequate and satisfactory workforce and controlling the personnel policies and programmes of the organization are the major responsibilities of the human resource management.

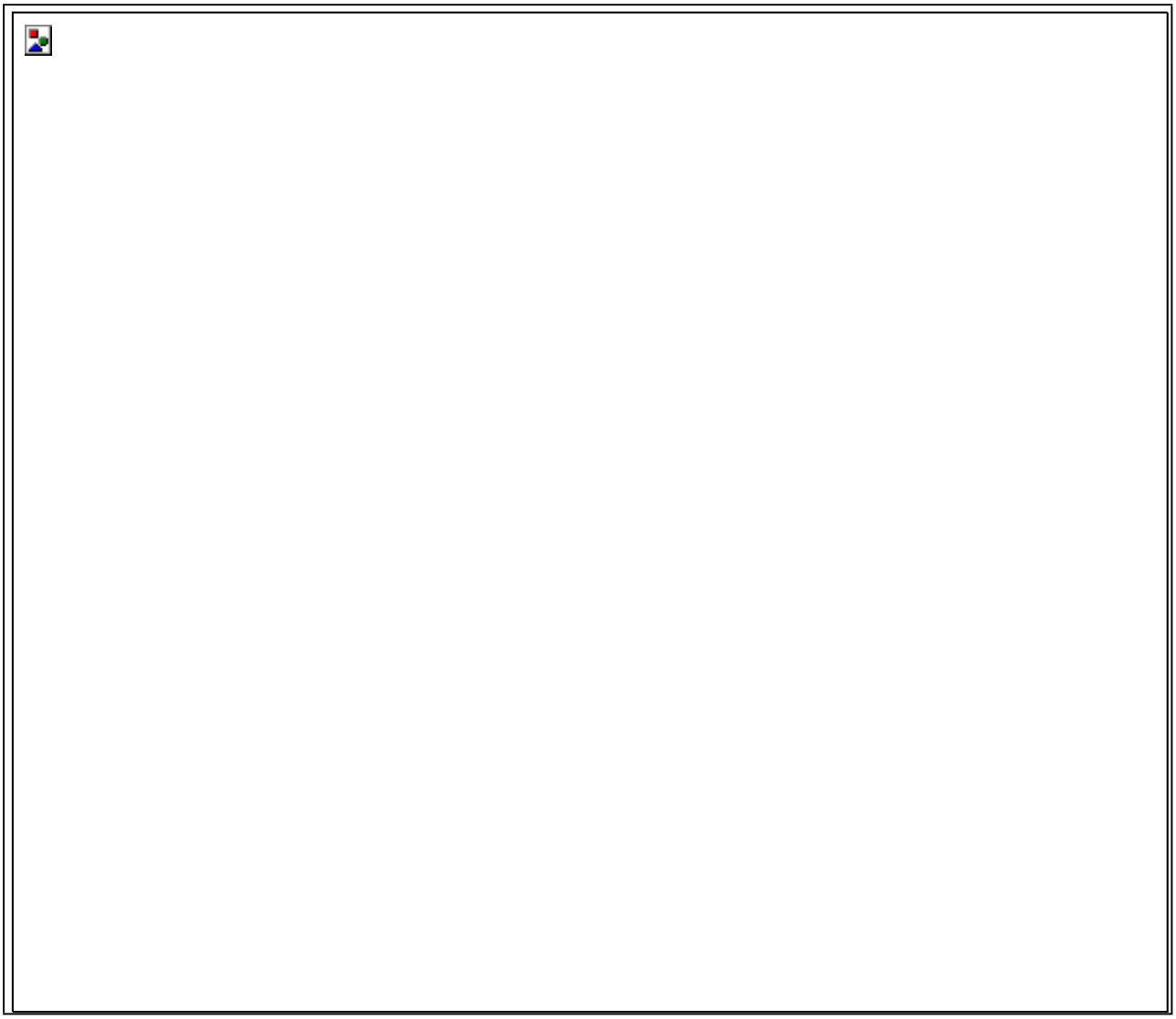
In addition to different functions, in recent years following additional responsibilities are also expected from modern resource management system:

(i) Equal employment opportunity.

(ii) Occupational safety and health.

(iii) Employment retirement income security.

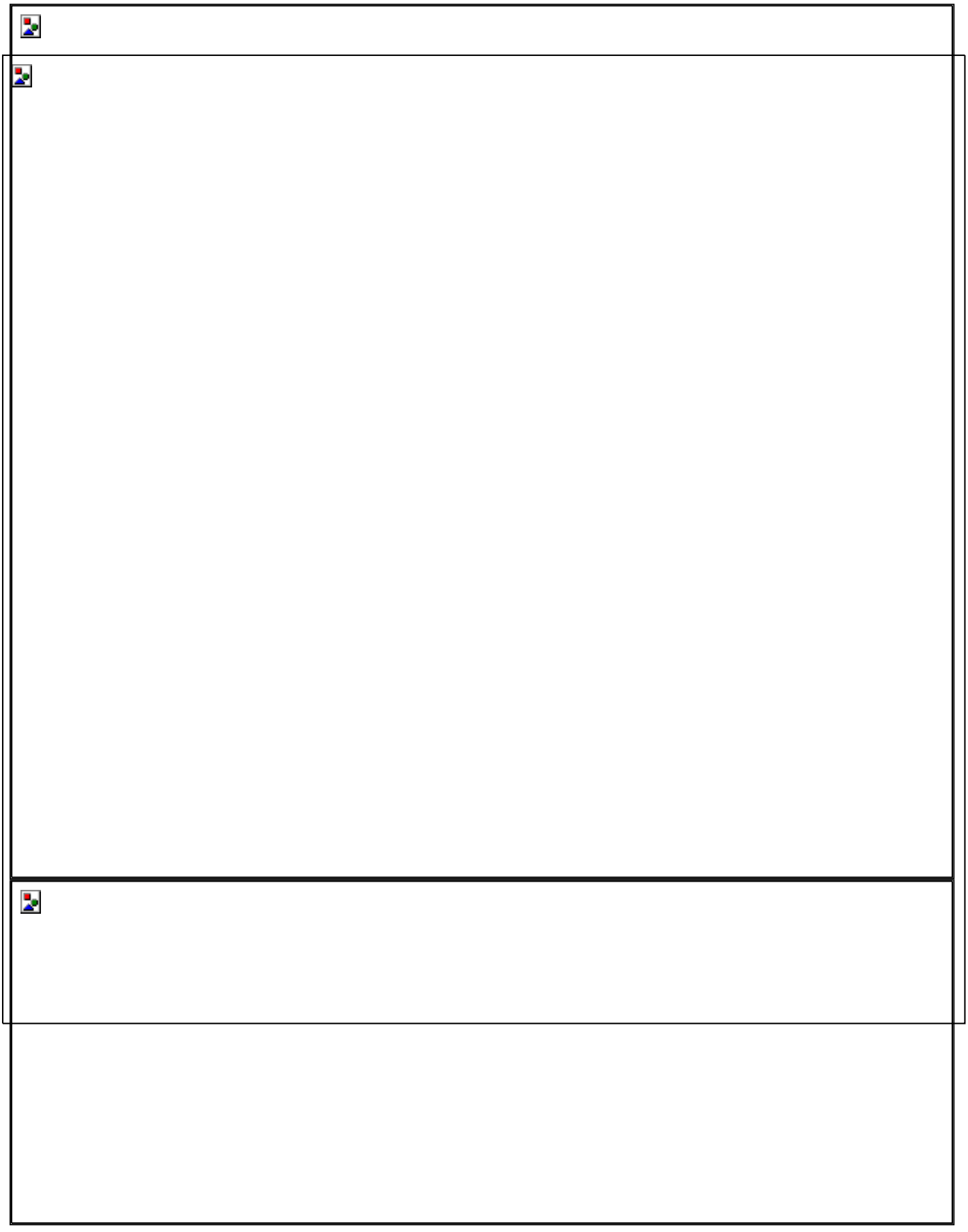
(iv) Upliftment of affected classes, a social responsibility.



FUNCTIONS AND OBJECTIVES OF PERSONNEL MANAGEMENT:

Personnel Management functions are generally divided into planning, organising, staffing, motivating and controlling aspects.

Major functions and objectives are given hereunder:



NATURE OF PERSONNEL MANAGEMENT:

The following points will bring out the nature of personnel management:

1. **Managing People:** Personnel management is concerned with managing people at work. It does not manage only organized or unorganized workers in the organization, but everyone working in the enterprise. It covers all persons including clerical staff, executives, and managers.

2. **Concerned with Employees:** Personnel management deals with employees both as individuals as well as in groups. The aim is to motivate people for getting best results from them.

3. **Helping Employees:** The employees are helped to develop their talent fully by providing them appropriate opportunities. This will give them job satisfaction and may improve their performance at work.

4. **Universal Application:** Personnel management may be used everywhere and in every type of organization. It is equally useful in a government, semi-government, non-profit organizations as is beneficial to industrial and commercial houses. It is a part of general management and has roots extending throughout and beyond each organization.

5. **Continuous Application:** Personnel management is continuously used in every type of situation. It is not something which may be used here and there or now and then. In the words of George Terry, "It cannot be turned on and off like water from a faucet; it cannot be practiced only one hour each day or one day a week. Personnel management requires a constant alertness and awareness of human relations and their importance in everyday operations.

OBJECTIVES OF PERSONNEL MANAGEMENT:

According to Michael J. Jueius, personnel management should aim at:

(a) Attaining economically and effectively the organizational goals,

(b) Serving to the highest possible degree the individual goals, and

(c) Preserving and advancing the general welfare of the community.

Personnel Management has been assigned the task of not only helping the organization and its employees but also the society at large.

The objectives of personnel management are discussed as follows:

1. **Enterprise Objectives:** The primary objective of personnel management is to help in achieving organizational goals. There will be a need for co-operation from everyone in the organization for achieving business goals. This requires that such persons should be employed who are capable of taking up the jobs assigned to them.

   They should also be given proper training for undertaking the work effectively. This will be ensured by a suitable policy of recruitment, training and placement. The satisfaction of employees should be ensured to get their wholehearted co-operation. This may be done by looking after their convenience at work and offering them financial and other incentives. The enterprise objectives will only be achieved if everybody works for their attainment. Employees should be motivated to contribute their maximum to the organizational goals.

2. **Personnel Objectives:** Personnel management aims at the material and mental satisfaction to each employees in the organization. This will be possible when employees are provided with proper work environment and job satisfaction. The work place should be neat and clean and properly ventilated. Job satisfaction will include good remuneration, job security, avenues for promotion, financial and other incentives for improving performance.
3. **Social Objectives:** Personnel management also aims at preserving and advancing general welfare of the community. An enterprise owes a responsibility to the society at large. It can serve the society by creating more employment opportunities, producing quality goods at cheap rates. It can also help society by using productive resources in a best possible way and minimizing their waste.

ROLE OF PERSONNEL MANAGER:

Personnel manager is the head of personnel department. He performs both managerial and operative functions of management. His role can be summarized as:

- Personnel manager provides assistance to top management- The top management are the people who decide and frame the primary policies of the concern. All kinds of policies related to personnel or workforce can be framed out effectively by the personnel manager.
- He advices the line manager as a staff specialist- Personnel manager acts like a staff advisor and assists the line managers in dealing with various personnel matters.
- As a counsellor - As a counsellor, personnel manager attends problems and grievances of employees and guides them. He tries to solve them in best of his capacity.
- Personnel manager acts as a mediator- He is a linking pin between management and workers.
- He acts as a spokesman- Since he is in direct contact with the employees, he is required to act as representative of organization in committees appointed by government. He represents company in training programs

CONCEPT OF INDUSTRIAL RELATIONS (IR):

The term 'Industrial Relations' comprises of two terms: 'Industry' and 'Relations'. "Industry" refers to "any productive activity in which an individual (or a group of individuals) is (are) engaged". By "relations" we mean "the relationships that exist within the industry between the employer and his workmen."

The term industrial relations explains the relationship between employees and management which stem directly or indirectly from union-employer relationship.

DEFINITIONS:

The term 'industrial relations' has been variously defined. **J.T. Dunlop** defines industrial relations as "the complex interrelations among managers, workers and agencies of the governments".

According to **Dale Yoder** "industrial relations is the process of management dealing with one or more unions with a view to negotiate and subsequently administer collective bargaining agreement or labour contract".

The term 'Industrial Relations' comprises of two terms: **'Industry' and 'Relations'. "Industry"** refers to "any productive activity in which an individual (or a group of individuals) is (are) engaged". By "relations" we mean **"the relationships that exist within the industry between the employer and his workmen."** The term industrial relations explain the relationship between employees and management which stem directly or indirectly from union-employer relationship.

Industrial relations are the relationships between employees and employers within the organizational settings. The field of industrial relations looks at the relationship between management and workers, particularly groups of workers represented by a union. Industrial relations are basically the interactions between employers, employees and the government, and the institutions and associations through which such interactions are mediated.

Industrial Relation is a relation between employer and employees, employees and employers and employees and trade unions, and the "process by which people and their organizations interact at the place of work to establish the terms and conditions of employment." - Industrial dispute Act 1947

The HR Employee Relations Manager directs the organization's employee relations function. They develop employee relations policies and ensure consistent application of company policies and procedures. In addition, they are responsible for employee dispute resolution procedures, performing internal audits, and taking appropriate action to correct any employee relations issues.

IMPORTANCE OF INDUSTRIAL RELATIONS:

The healthy industrial relations are key to the progress and success. Their significance may be discussed as under:

- **Uninterrupted production –** The most important benefit of industrial relations is that this ensures continuity of production. This means, continuous employment for all from manager to workers. The resources are fully utilized, resulting in the maximum possible production. There is uninterrupted flow of income for all. Smooth running of an industry is of vital importance for several other industries; to other industries if the products are intermediaries or inputs; to exporters if these are export goods; to consumers and workers, if these are goods of mass consumption.
- **Reduction in Industrial Disputes –** Good industrial relations reduce the industrial disputes. Disputes are reflections of the failure of basic human urges or motivations to secure adequate satisfaction or expression which are fully cured by good industrial relations. Strikes, lockouts, go-slow tactics, gherao and grievances are some of the reflections of industrial unrest which do not spring up in an atmosphere of industrial peace. It helps promoting co-operation and increasing production.

- **High morale –** Good industrial relations improve the morale of the employees. Employees work with great zeal with the feeling in mind that the interest of employer and employees is one and the same, i.e. to increase production. Every worker feels that he is a co-owner of the gains of industry. The employer in his turn must realize that the gains of industry are not for him along but they should be shared equally and generously with his workers. In other words, complete unity of thought and action is the main achievement of industrial peace. It increases the place of workers in the society and their ego is satisfied. It naturally affects production because mighty co-operative efforts alone can produce great results.

- **Mental Revolution –** The main object of industrial relation is a complete mental revolution of workers and employees. The industrial peace lies ultimately in a transformed outlook on the part of both. It is the business of leadership in the ranks of workers, employees and Government to work out a new relationship in consonance with a spirit of true democracy. Both should think themselves as partners of the industry and the role of workers in such a partnership should be recognized. On the other hand, workers must recognize employer's authority. It will naturally have impact on production because they recognize the interest of each other.

- **Reduced Wastage –** Good industrial relations are maintained on the basis of cooperation and recognition of each other. It will help increase production. Wastage of man, material and machines are reduced to the minimum and thus national interest is protected.

Thus, it is evident that good industrial relations is the basis of higher production with minimum cost and higher profits. It also results in increased efficiency of workers. New and new projects may be introduced for the welfare of the workers and to promote the morale of the people at work. An economy organized for planned production and distribution, aiming at the realization of social justice and welfare of the massage can function effectively only in an atmosphere of industrial peace. If the twin objectives of rapid national development and increased social justice are to be achieved, there must be harmonious relationship between management and labor.

OBJECTIVES OF INDUSTRIAL RELATIONS:

The main objectives of industrial relations system are:

1. To safeguard the interest of labor and management by securing the highest level of mutual understanding and good-will among all those sections in the industry which participate in the process of production.
2. To avoid industrial conflict or strife and develop harmonious relations, which are an essential factor in the productivity of workers and the industrial progress of a country.
3. To raise productivity to a higher level in an era of full employment by lessening the tendency to high turnover and frequency absenteeism.

4. To establish and promote the growth of an industrial democracy based on labor partnership in the sharing of profits and of managerial decisions, so that ban individuals personality may grow its full stature for the benefit of the industry and of the country as well.
5. To eliminate or minimize the number of strikes, lockouts and gheraos by providing reasonable wages, improved living and working conditions, said fringe benefits.
6. To improve the economic conditions of workers in the existing state of industrial managements and political government.
7. Socialization of industries by making the state itself a major employer
8. Vesting of a proprietary interest of the workers in the industries in which they are employed.

NATURE OF INDUSTRIAL RELATIONS:

Essentially, IR is concerned with the relationship between management and workers and the role of regulatory mechanism in resolving any industrial dispute. A formal definition is:

"Concerned with the systems, rules and procedures used by unions and employers to determine the reward for effort and other conditions of employment, to protect the interests of the employed and their employers, and to regulate the ways in which employers treat their employees."

Specifically, IR covers the following areas:

1. Collective bargaining.
2. Role of management, unions, and government.
3. Machinery for resolution of industrial disputes.
4. Individual grievance and disciplinary policy.
5. Labour legislation.
6. Industrial relations training.

IMPORTANCE OF INDUSTRIAL RELATIONS:

IR is the key for increased productivity in industrial establishment. For example, at the Alwar plant of Eicher Tractors, productivity went up from 32% between 1994 and 1996 to 38% in 1997, the production of Engine cylinders has gone up from 29390 (in 1995-96) to 32501 (in 1996-97). This increase has been possible because of peaceful IR. IR has moral dimensions, too. It is unethical on the part of any management to take advantage of the helplessness of workers and exploit them. Unemployment compels workers - particularly illiterate and unskilled - to accept jobs, inhuman working conditions and wages notwithstanding.

IR assumes relevance in this context. One of its objectives is to protect workers interest and to improve their economic conditions.

IR seeks to protect the right of managers too. Managers expects workers to observe code of discipline, not to join illegal strikes, not to indulged in damaging the companies properties, not to assault supervisors or peers,

and not to come inebriated the workplace. Where workers behaviour deviates from expected lines. It is management's prerogative to take action.

There is a set procedure for handling any act of indiscipline or indiscretion on the part of an employee and if the management satisfied the procedure, it is justified in taking action or even removing the employee from service.

Little do all of us realise that it is the people who creates problem everywhere and it is only who can find solutions too. If there is a problem from employees, there is a solution also. Viewing every problem seriously and resorting the manipulative style of IR which emphasise the need the labour is check by floating stooge unions, buying up unions, and striking clandestine deals with powerful politicians do no good to managers or to the organization they represent. the field of ir needs a new look, a look which is free from suspicion, prejudice and ill will towards workers.

APPROACHES TO INDUSTRIAL RELATIONS:

The scenario of IR is perceived differently by different people. For some, IR is related to class conflict, other perceive it in terms of mutual cooperation and still others understand it in terms of competing interests of various groups. HR managers are expected to understand these varying approaches because they provide the theoretical understanding for much of the role of HRM.

The three popular approaches to IR are unitary approach, pluralistic approach and Marxist approach.

1. Unitary Approach
2. Pluralistic Approach
3. Marxist Approach

1. **UNITARY APPROACH:** Under unitary approach, IR is grounded in mutual cooperation, individual treatment, teamwork and shared goals. Workplace conflict is seen as a temporary aberration, resulting from poor management, from employees who do not mix well with the organizations culture. Unions cooperate with the management and the managements rights to manage is accepted because there is no "we-they" feeling. The underline assumption is that everyone benefits when the focus is on common interest and promotion of harmony. Conflict in the form of strikes is not regarded as necessary but destructive.

   Advocates of the unitary approach emphasise on a reactive IR strategy. They seek that negotiations with employees. Participation of government, tribunals, and unions is not sought or are seen as been necessary harmonious employee relations.

   The unitary approach is being criticized as a tool for seducing employees away from unionism and socialism. It is also criticized as manipulative and exploitative.
2. **PLURALISTIC APPROACH:** The pluralistic approach totally departs from the unitary approach. The pluralistic approach perceives:

a. Organizations as coalition of competing interest, where the management's role is to mediate amongst the different interest groups.
b. Trade unions as legitimate representatives of employee interests.
c. Stability in IR as the product of concessions and compromises between management and unions.

Legitimacy of the management authority is not automatically accepted. Conflict between the management and workers is understood as inevitable and in fact, is viewed as conductive for innovation and growth. Employees join unions to protect their interest and influence decision making by the management. Unions thus balance the power between the management and employees. In the pluralistic approach, therefore, a strong union is not only desirable but necessary. Similarly, society's interests are protected by state intervention through legislation and industrial tribunals which provide orderly process for regulation and resolutions of conflict.

The theories on pluralism were evolved in the mid-sixties and early seventies when England witnessed a resurgence of industrial conflicts. However, the recent theories of pluralism emanate from British scholars, and in particular from Flanders and Fox. According to pluralists, industrial conflict is inevitable and it needs to contain within the social mechanism of collective bargaining, conciliation and arbitration.

3. **MARXIST APPROACH:** Marxist, like the pluralistic, regard conflict between employers and employees as inevitable. However, pluralists believe that the conflict is inevitable in all organizations. Marxists see it as a product of the capitalist society.

Adversarial relations in the workplace are simply one aspect of class conflict. The Marxist approach focuses on the type of society in which an organization functions. Conflict arises not just because of competing interest within the organization, but because of the division within society between those who own or manage the means of production and those who have only their labour to offer. Industrial conflict is thus seen as being synonymous with political and social unrest.

INDUSTRIAL RELATIONS STRATEGY

It is necessary to have a clear cut strategy for IR, although the management of IR is essentially a knee jerk reaction to events and problems and is, therefore, far removed from the world of strategic thinking and planning. Since employer-employee relations are usually presumed to be satisfactory until they get out of hand, managers, rarely, feel the need to act before the trouble breaks out.

But the reactive strategy cannot continue for long. Growing competition, difficult economic environment, rising labour cost, and low productivity compel business leaders to think and plan proactive strategies towards IR.

FACTORS AFFECTING EMPLOYEE RELATIONS STRATEGY

Two sets of factors, internal as well as external influence an IR strategy. The internal factors are:

1. The attitude of management to employees and unions.
2. The attitude of employees to management.

3. The attitudes of employees to unions.
4. The inevitability of the differences of opinion between management and union.
5. The extent to which the management can or wants to exercise absolute authority to enforce decision affecting the interests of employees.
6. The present and likely future strength of the union.
7. The extent to which there is one dominating union or the existence of multiple unions leading to inter-union rivalry.
8. The extent to which effective and agreed procedures for discussing and resolving grievances or handling disputes exists within the company.
9. The effectiveness of managers and supervisors in dealing with problems and disputes related to IR.
10. The prosperity of the company, the degree to which is expanding, stagnating or running down and the extent to which technological changes are likely to affect employment conditions and opportunities.

The external factors affecting IR strategy are:

1. The militancy of unions - nationally or locally
2. The effectiveness of the union and its officials and the extent to which the officials can and do control the activities of supervisors within the company.
3. The authority and effectiveness of the employers association.
4. The extent to which bargaining is carried out at national, local or plant level.
5. The effectiveness of any national or local procedures, agreements that may exist.
6. The employment and pay situation - nationally or locally.
7. The legal framework within which the IR exists.

JOB EVALUATION

DEFINITIONS:

Below are given some important definitions of job analysis:

Job Evaluation involves determination of relative worth of each job for the purpose of establishing wage and salary differentials. Relative worth is determined mainly on the basis of Job Description and Job Specification only. Job Evaluation helps to determine wages and salary grades for all jobs. Employees need to be compensated depending on the grades of jobs they perform. Remuneration must be based on the relative worth of each job. Ignoring this basic principle results in inequitable compensation and attendant ill effects on employees' morale. A perception of inequity is a sure way of De-motivating an employee.

- In the words of **Edwin B. Flippo.** "Job evaluation is a systematic and orderly process of determining the worth of a job in relation to other jobs."

- According to **Kimball and Kimball Jr.**, "Job evaluation represents an effort to determine the relative value of every job in a plant and to determine what the fair basic wage for such a job should be."

- According to **Bethel, Atwater and Smith et at,** "Job evaluation as a personal term has both a specific and genetic meaning specifically, it means job rating or the grading of occupations in terms of duties; generally it means the entire field of wages and salary administration along modern lines"

- According to **International Labour Organization,** "Job evaluation may be defined as an attempt to determine and compare the demands which the normal performance of particular job makes on normal workers without taking account of the individual abilities or performance of the workers concerned."

- In the words of **Dale Yoder,** "Job evaluation is a practice which seeks to provide a degree of objectivity in measuring the comparative value of jobs within an organization and among similar organizations."

- According to **Bureau of Labour Statistics,** "Job evaluation is the evaluation or rating of job to determine their position in job hierarchy. The evaluation may be achievement through asssignment of points or the use of some other systematic rating method for essential job requirements such as skill, experience and responsibility."

Jobs are evaluated on the basis of content and placed in order of importance. This establishes Job Hierarchies, which becomes the basis for satisfactory wage differentials among various jobs. Jobs are ranked (not jobholders)

Job evaluation is a formal and systematic approach to analysing jobs and categorizing them in regard to their relative worth in an organization. Job evaluations are usually based on compensation factors (skill set needed to perform the job, working conditions and job duties) rather than on the employee.

Job evaluation is a systematic way of determining the value/worth of a job in relation to other jobs in an organization

OBJECTIVES OF JOB EVALUATION:

The main objective of job evaluation is to determine relative worth of different jobs in an organization to serve as a basis for developing equitable salary structure. States an ILO Report the aim of the majority of systems of job evaluation is to establish, on agreed logical basis, the relative values of different jobs in a given plant or machinery i.e. it aims at determining the relative worth of a job. The principle upon which all job evaluation schemes are based is that of describing and assessing the value of all jobs in the firms in terms of a number of factors, the relative importance of which varies from job to job.

The objectives of job evaluation, to put in a more orderly manner are to:

1. Provide a standard procedure for determining the relative worth of each job in a plant.
2. Determine equitable wage differentials between different jobs in the organization.
3. Eliminate wage inequalities.

4. Ensure that like wages are paid to all qualified employees for like work.
5. Form a basis for fixing incentives and different bonus plans.
6. Serve as a useful reference for setting individual grievances regarding wage rates.
7. Provide information for work organization, employees' selection, placement, training and numerous other similar problems.
8. Provide a benchmark for making career planning for the employees in the organization.

PRINCIPLES OF JOB EVALUATION:

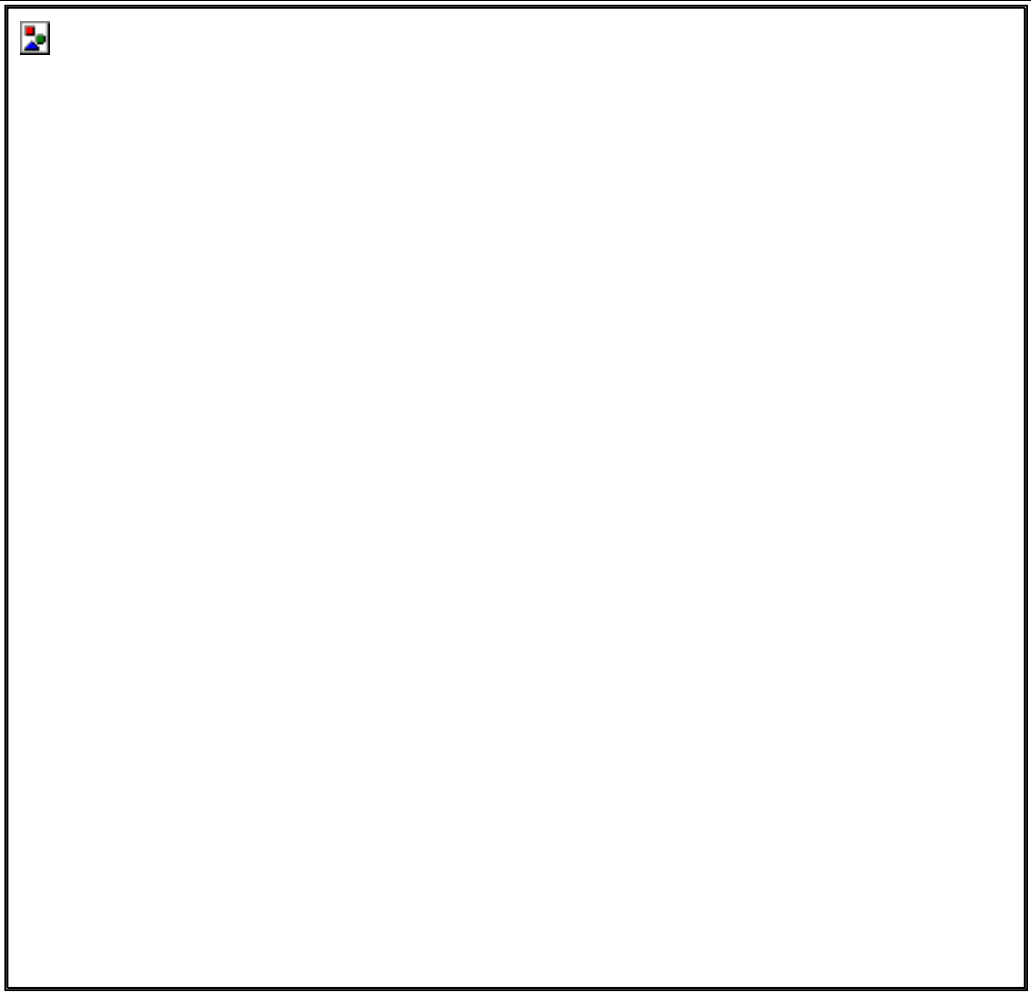
The job evaluation has certain principles. These principles are supposed to be kept in the mind of the job evaluators. These principles are not only directives of proper job evaluation but also provide clarity in the process of evaluation.

According to Kress, these principles are:

1. Rate the job and the jobber. Each element should be rated on the basis of what the job itself requires;
2. The elements selected for rating purposes should be easily explainable in terms and a few in numbers as will cover the necessary requisites for every job without any overlapping;
3. The elements should be clearly defined and properly selected;
4. Any job rating plan must be sold to foremen and employees. The success in selling it will depend on a clear-cut explanation and illustration of the plan;
5. Foreman should participate in the rating of jobs in their own departments;
6. Maxim mum co-operation can be obtained from employees when they themselves have an opportunity to discuss job ratings and;
7. Too many occupational wages should not be established. It would be unwise to adopt an occupational wage for each total of point values.

PROCEDURE OF JOB EVALUATION:

Though the common objective of job evaluation is to establish the relative worth of jobs in a job hierarchy, there is no common procedure of job evaluation followed by all organizations. As such, the procedure of job evaluation varies from organization to organization. For example, a job e valuation procedure may consist of the eight stages as delineated in Figure 14.1.



1) **Preliminary Stage:** This is the stage setting for job evaluation programme. In this stage, the required information's obtained about present arrangements, decisions are made on the need for a new programme or revision of an existing one and a clear cut choice is made of the type of programme is to be used by the organization.
2) **Planning Stage:** In this stage, the evaluation programme is drawn up and the job holders to be affected are informed. Due arrangements are made for setting up joint working parties and the sample of jobs to be evaluated is selected.
3) **Analysis Stage:** This is the stage when required information about the sample of jobs is collected. This information serves as a basis for the internal and external evaluation of jobs.
4) **Internal Evaluation Stage:** Next to analysis stage is internal evaluation stage. In the internal evaluation stage, the sample of bench-mark jobs are ranked by means of the chosen evaluation scheme as drawn up at the planning stage. Jobs are then graded on the basis of data pending the collection of market rate data. Relative worth of jobs is ascertained by comparing grades between the jobs.
5) **External Evaluation Stage:** In this stage, information is collected on market rates at that time.
6) **Design Stage:** Having ascertained grades for jobs, salary structure is designed in this stage.
7) **Grading Stage:** This is the stage in which different jobs are slotted into the salary structure as designed in the preceding stage 6.

8) **Developing and Maintaining Stage:** This is the final stage in a job evaluation programme. In this stage, procedures for maintaining the salary structure are developed with a view to accommodate inflationary pressures in the salary levels, grading new jobs into the structure and regarding the existing jobs in the light of changes in their responsibilities and market rates.

In India, the Indian Institute of Personnel Management, Kolkata has suggested the following five steps to be taken to develop a job evaluation programme:

1. Analyze and Prepare Job Description
2. Select and Prepare a Job Evaluation Programme/Plan
3. Classify Jobs
4. Install the Programme
5. Maintain the Programme

These steps are self-explanatory. Hence are not discussed in detail.

FEATURES OF JOB EVALUATION:

The primary objective of job evaluation is to find out the value of work, but this is a value which varies from time to time and from place to place under the influence of certain economic pressure, not least of which is the worth of money itself. The main features of job evaluations are:

- To supply bases for wage negotiation founded on facts rather than on vague intermediate ideas.
- It attempts to assess jobs, not people.
- Job evaluation is the output provided by job analysis.
- Job evaluation does not design wage structure, it helps in rationalising the system by reducing number of separate and different rates.
- Job evaluation is not made by individuals rather it is done by group of experts.
- Job evaluation determines the value of job. Further the value of each of the aspects such as skill and responsibility levels are also related and studied in connection with the job.
- Job evaluation helps the management to maintain high levels of employee productivity and employee satisfaction.

THE OBJECTIVES OF JOB EVALUATION:

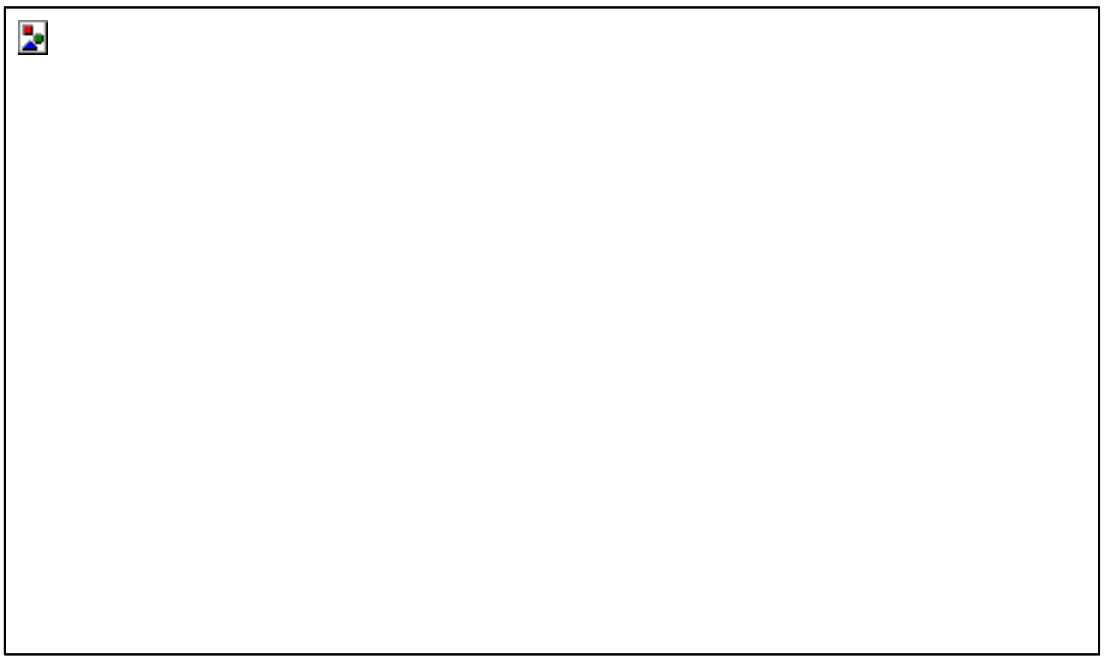
- To establish an orderly, rational, systematic structure of jobs based on their worth to the organization.
- To justify an existing pay rate structure or to develop one that provides for internal equity.
- To assist in setting pay rates that are comparable to those of in similar jobs in other organizations to compete in market place for best talent.
- To provide a rational basis for negotiating pay rates when bargaining collectively with a recognized union.
- To ensure the fair and equitable compensation of employees in relation to their duties.
- To ensure equity in pay for jobs of similar skill, effort, responsibility and working conditions by using a system that consistently and accurately assesses differences in relative value among jobs and

- To establish a framework of procedures to determine the grade levels and the consequent salary range for new jobs or jobs which have evolved and changed.
- To identify a ladder of progression for future movement to all employees interested in improving their compensation.
- To comply with equal pay legislation and regulations determining pay differences according to job content.
- To develop a base for merit or pay-for-performance.

JOB EVALUATION METHODS:

After job analysis preparations of job descriptions comes the essential stage of job evaluation, namely, the systematic comparison of jobs in order to establish a job hierarchy. The techniques which have been commonly used tend to fall into one of the two main categories:

- Non-analytical or Non-quantitative or summary methods
- Analytical or quantitative methods.



Qualitative methods are:

I. Job Ranking
II. Job Classification or grading

Quantitative methods are:

I. Factor Comparison
II. Point rating or assessment

QUALITATIVE METHODS ARE:

I. Job Ranking: The simplest and most common technique for job evaluation employs a system whereby human resources associates or consultants rank jobs in an organization based on a single factor, such as difficulty or education required to effectively perform the job. They then base compensation on ranking order with the highest ranked position earning the highest pay. This least expensive method of job evaluation works well for smaller businesses with tight budgets. Although this method can prove

effective, its analytical system does not reach deep enough to determine other things associated with job evaluation, such as the value of the job to the individual organization or experiential competencies necessary to properly perform the job.

- **Point Method:** A more complex job evaluation technique, the point method, requires evaluators to assign points to a number of compensation characteristics based on skill level, responsibility, effort required and working conditions. They then assess the level to which each of these are present in the job and assign points accordingly. The jobs with the highest points garner the highest pay with this popular technique.

- **Factor Comparison:** Factor comparison, a sophisticated, yet time-consuming method, utilizes the techniques found in several job evaluation schemes. The first step in factor comparison involves assessing each job based on characteristics used in the point method, but without assigning points. Next, evaluators analyze their findings against the market rate of pay for the compensation factors ranked in the first step. Finally, they establish external benchmark jobs that they use to compare to the job and its compensable characteristics to determine rate of pay.

II. **Job Classification:** The classification method requires that evaluators categorize jobs into groups with relatively the same value to a business. The groups are commonly called grades. Evaluators categorize the grades with similar compensation characteristics together. The characteristics may include level of responsibility required, competencies required and physical exertion necessary to perform the job. Those evaluating the positions may choose to include other characteristics, such as education or security clearance levels required.

QUANTITATIVE METHODS ARE:

I. **Factor Comparison:** This is a combination of both rating and point rating methods. It means rates jobs by comparing them and makes analysis by breaking jobs into compensable factors. This system is usually used to evaluate white collar, professional and managerial positions.

II. **Point Rating or Assessment:** This is most widely used system of job evaluation. The method evaluates the compensable factors of each job. It involves a more detailed, quantitative and analytical approach to the measurement of job work. Under this method jobs are broke down based on various identifiable factors such as skill, effort, training, knowledge, hazards and responsibilities and so on. Thereafter, points are allocated to each of these factors. Weights are given to factors depending on their importance to perform the job. Points so allocated to various factors of a job are then summed. Then, the jobs with similar total of points are placed in similar pay grades. The sum of points gives an index of the relative significance of the jobs that are rated

ADVANTAGES OF JOB EVALUATION:

Job evaluation is a process of determining the relative worth of a job. It is a process which is helpful even for framing compensation plans by the personnel manager. Job evaluation as a process is advantageous to a company in many ways:

1. **Reduction in inequalities in salary structure:** It is found that people and their motivation is dependent upon how well they are being paid. Therefore the main objective of job evaluation is to have external and internal consistency in salary structure so that inequalities in salaries are reduced.
2. **Specialization:** Because of division of labour and thereby specialization, a large number of enterprises have got hundred jobs and many employees to perform them. Therefore, an attempt should be made to define a job and thereby fix salaries for it. This is possible only through job evaluation.
3. **Helps in selection of employees:** The job evaluation information can be helpful at the time of selection of candidates. The factors that are determined for job evaluation can be taken into account while selecting the employees.
4. **Harmonious relationship between employees and manager:** Through job evaluation, harmonious and congenial relations can be maintained between employees and management, so that all kinds of salaries controversies can be minimized.
5. **Standardization:** The process of determining the salary differentials for different jobs become standardized through job evaluation. This helps in bringing uniformity into salary structure.
6. **Relevance of new jobs:** Through job evaluation, one can understand the relative value of new jobs in a concern

DRAWBACKS OF JOB EVALUATION:

In spite of many advantages, job evaluation suffers from the following drawbacks/limitations:

1. Though there are many ways of applying job evaluation in a flexible manner, rapid changes in technology and in the supply of and demand for particular skills, create problems of adjustment that may need further study.
2. When job evaluation results in substantial changes in the existing wage structure, the possibility of implementing these changes in a relatively short period may be restricted by the financial limits within which the firm has to operate.
3. When there are a large proportion of incentive workers, it may be difficult to maintain a reasonable and acceptable structure of relative earnings.
4. The process of job rating is, to some extent, inexact because some of the factors and degrees can be measured with accuracy.
5. Job evaluation takes a long time to complete, requires specialized technical personnel and is quite expensive.

MERIT RATING OF EMPLOYEES: DEFINITION, CONCEPT AND OBJECTIVES:

INTRODUCTION:

Merit Rating is also known as performance appraisal or performance evaluation. It is a systematic process for measuring the performance of the employees in terms of job requirements.

It utilizes various rating techniques for comparing individual employees in a work group in terms of personal qualities or deficiencies and the requirements of their respective jobs. It is an established fact that people differ in their abilities and aptitudes. These differences are natural to a great extent and cannot be eliminated even by providing same training and education facilities to them.

There will be some differences in the quality and quantity of work done by different workers even on the same job. Therefore it is essential for the management to know these differentials so that employees having better abilities may be rewarded and the wrong selection and placement maybe restricted or avoided.

CONCEPTS AND DEFINITIONS OF MERIT RATING:

According to Scot and Spriegel - "Merit-rating of an employee is the process of evaluating the employee's performance on the job in terms of the requirements of the job". It is a technique of assessing the worth of an employee with reference to job requirements.

According to Dale Yodder - "Refers to all formal procedures used in working organizations to evaluate personalities and contribution and potential of group members". In the words of Yodder all types of methods used in evaluating the worth of employees for the organization are termed as performance appraisal.

In views of Alford and Beaty - "Employees rating is the evaluation or appraisal or the relative worth to the company of a man's services on his job". According to his definition the contribution of employees on jobs and their usefulness to the company is assessed under performance appraisal.

Thus according to the above mentioned definitions merit-rating or performance appraisal is a systematic evaluation of employee's contribution to the organization in performance of their jobs. This evaluation is normally done by the immediate superior in the organization which is reviewed in turn by his superior. Not only the qualities, but deficiencies are also taken into consideration to improve the performance of employees.

While job evaluation aims at determining the worth of a job compared with other jobs, merit rating aims at evaluating the workers actually performing the jobs. The purpose behind merit rating is to suitably reward an employee on the basis of his merit.

Merit rating system being a scientific tool to assess individual abilities of workers brings out differences among workers. In merit rating system, a number of traits are measured to know an employee's worth.

The personal qualities of employees which are usually appraised through merit rating are as follows:

1. Knowledge, skill and experience of the work.
2. Aptitude for the work.

3. Quality of work done.
4. Quantity of work done.
5. Attendance and punctuality.
6. Reliability and integrity.
7. Supervisory qualities like leadership, initiative, self-confidence and sense of judgment.
8. Co-operation and discipline.
9. Quality of adjustability in unusual circumstances.

Each of the above traits is assigned point value and each employee is evaluated according to the degree of traits he possesses. The employees may be rated either individually in order of points they secure or they may be arranged in groups according to their common ratings.

IMPORTANCE OF MERIT RATING:

Merit rating has been developed as a valuable tool of personnel management. It has the following advantages:

1. It helps the supervisor in evaluating the performance of his subordinates which is helpful in knowing the different qualities. In this way, suitable task can be assigned to the labour force on the basis of their qualities.
2. It pinpoints defects of workers so that they may improve their performance.
3. Merit rating of workers helps in determining wage increases and promotions.
4. Merit rating reveals weaknesses of workers and indicates the areas in which systematic training is needed.
5. Merit rating develops a sense of confidence among workers because they are convinced of the basis of evaluation of their abilities. In this way, it is helpful in removing the grievances of workers.
6. Merit rating is helpful in determining the wages of workers on the basis of their abilities.

OBJECTIVES OF MERIT RATING:

People differ in abilities and aptitudes. Management should know these differences so that employees are assigned jobs according to their capability.

Main objectives of merit rating are as follows:

1. To assess the work of employees in relation to their job requirements.
2. To consider employees/workers for promotions, transfer, layoffs etc.
3. To assess the good and bad points in working of employees and then making suggestions for improvement.
4. To help in wage and salary administrations and taking decisions about incentives and increments to be given to the workers.

5. To evaluate skill and training capabilities of employees and helping in planning suitable training and development programmes for workers.
6. To know the problems faced by workers while doing various jobs.
7. To provide a basis for comparison to segregate efficient and inefficient workers.
8. To help management in placement/transfer to workers according to their capacity, interest, aptitude and qualifications.
9. To help supervisors to know their subordinates more closely for increasing their efficiency and improving productivity.

METHODS OF MERIT RATING:

The different methods of merit rating, merit rating plans or merit rating systems are discussed below:

1) Rating Scale Method:

The steps involved in Rating Scale method are:

(a) Define the merit factors (i.e., standards) to rate the employees.

The different factors, according to the nature of job may be as follows:

i. Standard of output,
ii. Quantity of output,
iii. Intelligence,
iv. Job knowledge,
v. Leadership,
vi. Integrity,
vii. Dependability,
viii. Education and experience,
ix. Efforts and initiative,
x. Adaptability,
xi. Co-operation,
xii. Judgment,
xiii. Character,
xiv. Loyalty, and
xv. Health and appearance.

The number of factors employed for rating an employee may vary from six to ten.

(b) Divide each factor into three to five different grades or degrees like Excellent, Very good, Good, Fair and Unsatisfactory.

(c) Impart certain points (marks) to each grade.

(d) The worth of an employee can be determined from the total points he gets for all his merit factors. On the basis of these points different workers can also be compared.

2) Check List Method:

The method employs a list of questions and several statements which are concerned with the employee performance on various aspects of the job and which are considered important for evaluating the merit of

an employee for that job. The questions are of Yes or No type. Each question or statement possesses certain points which when totalled together for all the relevant questions indicate the rating of an employee.

Advantages:

(i) It is a good method of merit rating.

(ii) It reduces Halo-Effect.

Disadvantages:

It is time consuming and very difficult to construct statements and prepare appropriate questions.

3) Employee Comparison Method:

The method compares a worker on a job with all other workers on the same job, in pairs. Suppose there are four workers namely W, X, Y and Z.

Then,

W is compared with X and suppose

W is better W is compared with Y and suppose Y is better

W is compared with Z and suppose W is better Next,

X is compared with Y and suppose Y is better

X is compared with Z and suppose Z is better

Y is compared with Z and suppose Y is better

The summary of the results shows that

W turned out to be better – 2 times

X turned out to be better – Nil.

Y turned out to be better – 3 times (maximum) and

Z turned out to be better – 1 time.

Therefore, the worker Y is taken to be the best worker.

This method consumes much time especially when the number of employees to be compared is large.

METHODS OF MERIT RATING:

- **Ranking Method:-** This is the simplest method in which all the employees are compared with one another. They are ranked in descending order from best to worst. This method has a serious limitation that it is not diagnostic to point the specific areas of weakness and strength of a worker. The method is highly subjective. The difference in rank does not provide the exact nature or quantum of merit-differential.

- **Paired Comparison Method**:-In this method, each member of the group is compared with remaining other members of the group. Each judgment is recorded in terms of score. These scores are added up to find the final ranking of each person.
- **Wage Incentive:**-Payment for labor or services to a worker, especially remuneration on an hourly, daily, or weekly basis or by the piece Wages" means compensation for labor or services rendered by an employee, whether the amount is determined on a time, task, piece, commission or other basis of calculation
- **Time Wage System:-** Under this system, wages are paid on the basis of time spent on the job irrespective of the amount of work done. The unit of time may be a day. A week, a fortnight or a month. In the past, daily wages have been the most common basis and, therefore, it came to be known as the 'Day Wage System'.
- **Piece Wage System:**-Under this system, remuneration is based on the amount of work done or output of a worker. One unit of output is considered as one piece and a specific rate of wage is paid per piece. Greater id the number of pieces produced by a worker, higher is his remuneration. Thus, a workman is paid in direct proportion to his output. It is called payment by results.

BENEFITS OR ADVANTAGES OF MERIT RATING:

Besides a few mentioned under objectives, other advantages of Merit Rating are as listed below:

(1) Merit rating develops the ability of a rater,
(2) Meritorious employees are encouraged,
(3) Employee-employer relations improve.
(4) It is easy to deal with the unions as merit rating is a systematic method to rate the employees.
(5) It involves lesser calculations as compared to other incentive schemes.

DISADVANTAGES OF MERIT RATING:

(1) It entails Halo Effect. Halo effect means the tendency of the rater to rate an employee consistently low, average or high in all jobs, simply basing upon the general impression formed by him about the employee.
(2) Correct results will not be obtained, if merit factors relevant to a particular job are, somehow or other omitted or points allocated to them are not fair.
(3) A rater may play safe and tend to impart average grade to an employee who otherwise deserves unsatisfactory rating.
(4) A rater, if he does not make enough personal contacts with each employee cannot rate them correctly.
(5) A rater (i.e., supervisor) may not like to degrade his subordinates who maybe excellent otherwise but not good at work.

(6) Merit rating does not reward employees immediately for their performance.

Merit-rating plays very important role in the human resource administration of a firm. Its advantages are:

DIFFERENCE BETWEEN MERIT RATING AND JOB EVALUATION:

1) **Rating or job/Employees:** Job evaluation is related with the rating of the job whereas merit rating is a systematic process or evaluation of the capacities and abilities of the man doing the job.
2) **Purpose:** The purpose of the job evaluation is to fix wages for the jobs by considering certain factors such as skill, responsibility etc. In case of merit rating, the purpose is to evaluate the employee for the purpose of promotion, training, pay increase or incentives etc.
3) **Job difference/Individual differences:** Job evaluation considers the differences in jobs whereas merit rating recognizes the individual differences.
4) **Objectives/Subjective Qualities:** The type of factors to be considered are objective in case of job evaluation, whereas in case of merit rating subjective qualities are considered.
5) **Performance of individual versus job:** Job evaluation becomes the basis of determining wages whereas merit rating is undertaken to find out the efficiency of the individual for doing specific jobs.
6) **Test of worth versus merit:** In job evaluation, an attempt is made to know the worth of a job in terms of certain factors such as responsibility and effort (mental as well as physical). Merit rating identifies the capacity and capability of an individual for doing specific job.
7) **Uses:** Job evaluation is meant for determining the wages on an employee. On the other hand, merit rating is utilized for placement and training etc.

WAGE INCENTIVE PLANS: OBJECTIVES, ADVANTAGES, LIMITATIONS AND TYPES:

Wage incentive refers to performance linked compensation paid to improve motivation and productivity. It is the monetary inducements offered to employees to make them perform beyond the acceptance standards.

According to the National Commission of Labour "wage incentives are extra financial motivation. They are designed to stimulate human effort by rewarding the person over and above the time rated remuneration, for improvements in the present or targeted results".

Scott defines it as "any formal and announced programme under which the income of an individual, a small group, a plant work force or all the employees of a firm are partially or wholly related to some measure of productivity output".

Human and nickerson define it in simple terms as "all the plans that provide extra pay for extra performance in addition to regular wages for a job".

OBJECTIVES OF WAGE INCENTIVE SCHEMES:

(i) To use wage incentives as a useful tool for securing a better utilisation of manpower, better productivity scheduling and performance control, and a more effective personnel policy.

(ii) To improve the profit of a firm through a reduction in the unit costs of labour and materials or both.

(iii) To increase a worker's earning without dragging the firm into a higher wage rate structure regardless of productivity.

(iv) To avoid additional capital investment for the expansions of production capacity.

PRINCIPLES OF A GOOD WAGE AND SALARY ADMINISTRATION:

a. Simple and easy to understand.
b. Union management agreement.
c. Time standard must be fixed.
d. Reward must be proportional to the effort.
e. Complaints and grievances must be properly attended to.
f. The plans should not change frequently and must be tried out continuously for some length of time.
g. Equity and fairness.
h. Workers must be made to understand the plan.
i. Method study must precede time standard.
j. There must be a min guaranteed payment.

ADVANTAGES OF INCISIVE PLANS:

Wage incentive plans benefit not only the employees but also the employers.

a. Wage incentive plans provide an opportunity for hardworking and ambitious workers to earn more.
b. It encourages employees to be innovative. They come out with more efficient ways of doing work by overcoming the problems related to productivity and wasteful practice.
c. Incentive plans help to improve discipline and industrial relations. Effective incentive plan helps in minimizing absenteeism, accidents etc.
d. The self-motivation on the part of the workers to work hard and improve performance so as to earn monetary rewards will reduce the cost of supervision.
e. The scientific work study undertaken before introducing the incentive plans helps in improving work flow, work methods etc.
f. The employees are encouraged to work as a team with mutual co-operation as their activities is interdependent, and any obstruction on the part of a worker can affect the output and rewards.
g. According to the National Commission on Labour, "wage incentive is the cheapest, quickest and surest means of increasing productivity."

LIMITATIONS:

a. Jealousy and conflicts among workers may arise when some workers earn more than others.

b. Unless strict check and inspections are maintained, quality may come under stake in the enthusiasm among workers to increase productivity.

c. In the absence of a ceiling on incentive earnings, some workers may spoil their health.

d. Strict vigilance becomes necessary to ensure that workers do not disregard safety regulation.

e. The cost and time of clerical work increases in introducing and administrating the incentive plans.

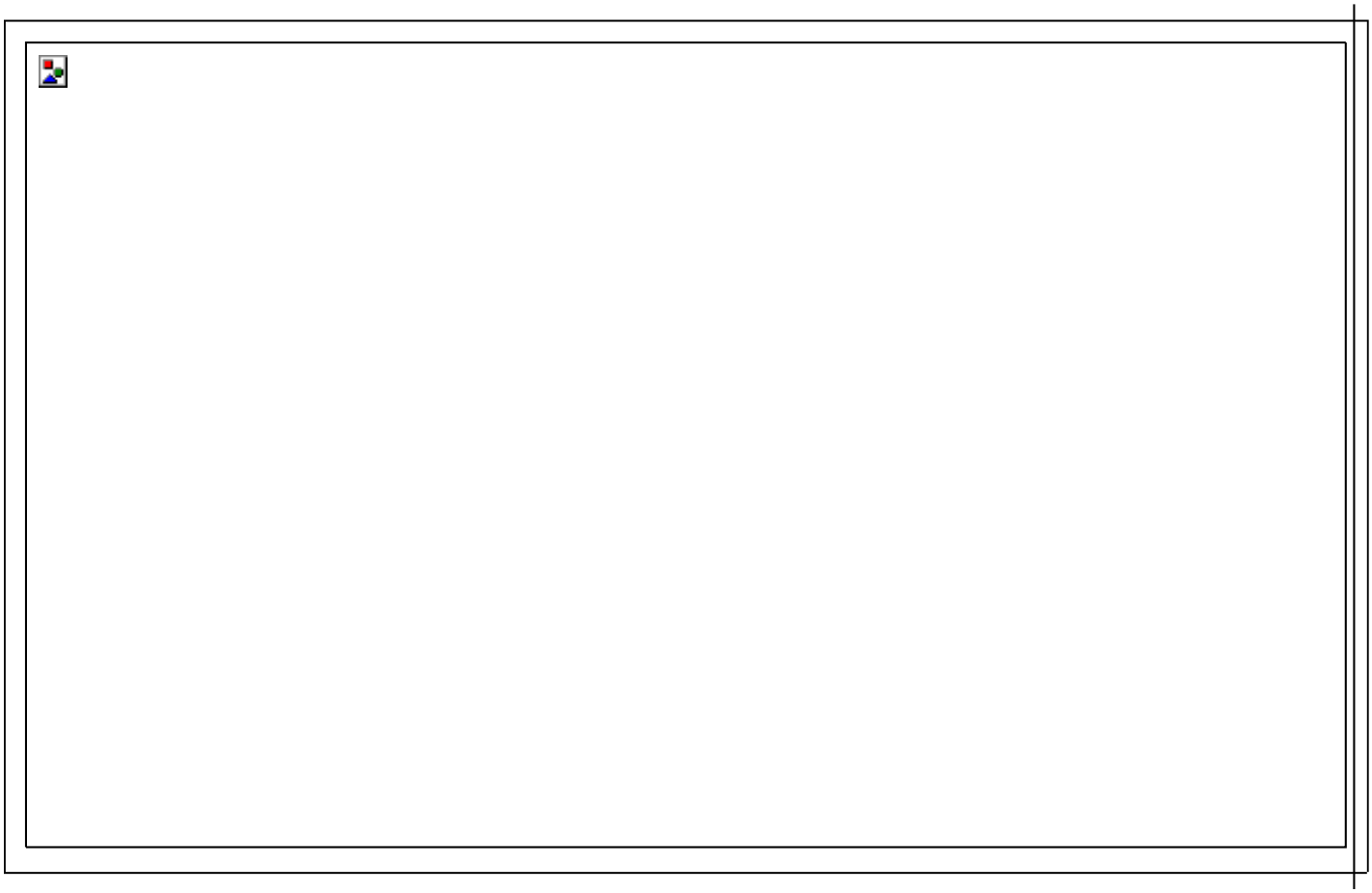
f. Whenever production flow is disrupted due to the fault of management, workers insist on compensation.

TYPES OF WAGE INCENTIVE PLANS:

The various incentive plans can be classified into two groups: 1. Individual Incentive Plans 2. Group Incentive Plans.

Following are the types of wage incentive plans.

They can be diagrammatically represented as below:



1. Straight Piece Rate Plan:

Under the straight piece rate plan workers are paid based on their output. For example, if the piece rate is Rs. 4 per piece of the product, then a worker who turns out 40 pieces/day earns Rs. 160 (Rs. 4 x 40) as his wage for that day. Whereas another employee who produces 32 pieces/ day earns Rs. 128 (Rs. 4 x 32 pieces). Hence a fast worker earns more compared to the slow worker.

Advantages:

i. Motivates the workers to increase their output.

ii. Simple and easy to understand.

iii. Improve productivity.

Disadvantages:

i. No guaranteed minimum wage. This makes workers insecure.

ii. Great disparity of earning between slow and fast workers.

iii. Wastage might increase.

iv. Quality of production may suffer as the workers concentrate on quantity.

v. Interpersonal relationship suffers due to jealousy and competition to earn more.

vi. Enforced idleness like electricity failure or machine breakdown, adversely affect earning of workers.

2. Standard Piece Rate with Guaranteed Minimum Wage:

Here the minimum guaranteed wage is fixed on hourly basis. A worker gets the minimum fixed wage/day plus the incentive for the number of pieces produced. To illustrate this, assume that there is 8 hour's shift the piece rate is Rs 4 and a minimum fixed wage of Rs 16/ hours (Rs 16 x 8 hours = Rs. 128 per day). The standard time/piece is 15 min.

Now, there are two workers A and B. (If worker A produces 25 prices/day then he earns: Rs. 128 (min. guaranteed wage) + Rs. 100 (Rs. 4 x 25 pcs) = Rs. 228/ day

If worker B produces 40 pieces / day then he earns Rs. 128 (min. guaranteed wage) + Rs. 160 (40 pieces x Rs. 4) = Rs. 228/ day)

Advantages:

i. Min. guarantee improves sense of security.

ii. Disparity between slow and faster workers is reduced.

Disadvantages:

i. Demotivate faster worker.

ii. Slow workers get higher piece rate viz Rs. 5.12 (128/ 25).

DIFFERENTIAL PIECE RATES:

he shortcoming of the above mentioned incentive plans have given way Differential piece rates. The differential piece rates are classified under two heads viz. Individual incentive plans and Group incentive plans.

INDIVIDUAL INCENTIVE PLANS:

The different plans here are discussed below:

(a) Halsey Plan:

The features of this plan are:

a. Min. wage is guaranteed.

b. Additional bonus is provided to workers who

Wage and Salary Administration 147 complete the job in less than the "standard time". Bonus is a certain proportion to the time saved. This proportion is fixed at 50% in this plan.

The total wage is calculated as:

$$T \times R + 50\% (S - J) \times R$$

Where,

J – time taken

R – Rate of wage

S – Standard time

50% – The bonus percentage.

Illustration:

S = 10 hours, J = 8 hours; R = Rs. 5 / Hr; Bonus = 50%

$\Phi = 8 \times 5 + (50/100) \times (10 - 8) \times 5$

Φ = Rs. 45.

Advantages:

i. Guaranteed min. wage exists.

ii. Simple and easy.

iii. Dispensed with time consuming and costly process of work study.

iv. Management share a part of bonus on time saved.

Disadvantages:

i. Workers get only half of the benefit of their efficiency.

ii. If the worker's rush through the job to save time, the quality may suffer.

iii. Workers object management in sharing bonus on time saved.

iv. Sufficient incentive is not provided to fast workers.

(b) Rowan Plan:

This is a modified form of Hasley Plan, developed by James Rowen of England. The Rowan Plan pays more than the Halsey Plan. This is possible if a worker completes the task in half the standard time of the task. If more than 50% time is saved then the bonus he earns decreases.

Therefore, Total wage = J x R + [J x R x (Time saved/std. time)]

Illustration:

S = 10 hours; J = 8 hours; R = Rs. 5 / hrs.

Φ =8 x 5 + [8 x 5+ (2/10)]

Φ = Rs. 48

Advantages:

i. Minimum guaranteed wage exists.
ii. Both the employees and the workers share the benefits of time saved.
iii. The efficient workers get bonus at diminishing rate if they save more than 50% of the standard time. This checks over-speeding.

Disadvantages:

i. Incentive provided for fast worker is not sufficient.
ii. Workers dislike management sharing bonus of time saved.

(c) Gantt plan:

This plan was developed by Henry L. Gantt. Here standard time for every task is fixed through time and motion study. Minimum time wage is guaranteed to all workers.

A worker who fails to complete the task within the standard time receives wages for actual time spent at the specified rate. Workers who achieve or exceed the standard get extra bonus varying between 20% to 50% of the hourly rate for the time allowed for the task.

Illustration:

(S) Suppose the standard time fixed for the job is 8 hours and (T) time rate is Rs. 10 hours and the rate of bonus is 25%, then a worker who completes the job in 10 hours will be paid Rs. 10 x 8 = Rs. 80. On the other hand the worker who completes the job in 6 hours will be paid Rs 100 (Rs. 80 + 25% of Rs. 80).

Advantages:

i. Minimum guarantee exists.
ii. Fast worker is paid bonus at higher rate proportional to their output.
iii. Standard worker is paid 20% bonus.
iv. Part of bonus is shared by the organization.

Disadvantages:

i. Sharing of bonus by organization is resentment.
ii. Disunity among the slow and the fast workers.

(d) Bedeaux Plan:

This plan is developed by Charles E. Bedeaux in 1911. Here the minimum time wage is guaranteed to all workers. The workers who complete the job within or more than the standard time are paid at the normal time rate.

Workers who complete the job in less than the standard time are paid bonus, generally 75% of the wage for the time saved and 25% to the foreman.

The wage rate is calculated as:

S x R + 75% of R (S – T)

Illustration:

S = 10 hrs; R = Rs. 5 / hrs; T = 8 hrs.

Then:

Φ = 10 x 5+ 75% (5) x (10-8)

= 50 + (3.75 x 2)

= 50 + 7.50

Φ = Rs. 57.50

Advantages:

i. Min. wage is guaranteed to all the workers.
ii. The foreman is motivated to the productivity as 25% of time saved is paid to him.
iii. This plan is suitable in factories wherein a worker is expected to perform different types of jobs.

Disadvantages:

i. Workers may resent sharing the bonus with foreman.
ii. Workers may find it difficult to understand the complete calculation involved in this method.

(e) Emerson's Efficiency Plan:

This plan was developed by Harrington Emerson. Here minimum wage is guaranteed. Workers are paid different bonus rates as per their efficiency level. Bonus is given at an increasing percentage beyond the prescribed level of efficiency (usually 66.67%). Efficiency is measured by comparing the actual time taken with the standard time.

Illustration:

S = 10 hrs, T = 8 hrs, R = Rs. 5 / hr.

Bonus = 10% upto 75 % efficiency

20% for 75%- 100%

30% beyond 100%

Φ = (T x R) + (percentage of bonus x T x R)

In this case, the efficiency level in (10/8) x 100 = 125% and,

Bonus at 30% is payable.

Total wage = 8 x 5 + (30/100) (8 x 5)

= 40+12

Rs. 51.

If worker A takes 16 hrs, then his bonus is nil.

If worker B takes 14 hrs, his bonus is (1/10) x 14 x 5.

If worker C takes 10 hrs, his bonus is (2/10) x 10 x 5.

If worker D takes 8 hrs, his bonus is (3/10) x 8 x 5.

Advantages:

i. Guaranteed time wage provides a sense of security to all the workers.
ii. It encourages healthy competition among workers.
iii. Bonus begins at 66.67% efficiency which is within the reach of many workers.

Disadvantages:

i. There is little incentive after 100% efficiency level.
ii. The plan is not very flexible or selective.
iii. Employer may fix the standard time at a low level making it impossible for most of the workers to earn bonus.

GROUP INCENTIVE PLAN:

A group incentive plan scheme is designed to promote effective teamwork, as the bonus is dependent on the performance and output of the team as a whole. Under group incentive plan, each employee is paid incentive on the basis of collective performance of his group to which he belongs. Within the group, each employee gets an equal share of the incentive.

Some of the group incentive plans are:

I. Priestman's Plan.

II. Scanlon's Plan.

I. Priestman's Plan:

In this plan workers are not considered individually but collectively. This system considers the productivity of all workers as a whole. Bonus is paid in proportion in excess of standard output per week. If in a year, the output increases either above the standard output or the output of the previous year, the wages are increased in the same ratio.

For example, if in 2009 the output per worker per unit time is 10 units and in year 2010 the output per worker per unit time comes out to be 12 units, the wages in 2010 will be 20% more than in 2009. The drawback of this system is that individual efficiency is not considered.

II. Scanlon's Plan:

A Scanlon plan is a type of gain sharing plan that pays a bonus to employees when they improve their performance or productivity by a certain amount as measured against a previously established standard. A typical Scanlon plan includes an employee suggestion program, a committee system, and a formula-based bonus system. A Scanlon plan focuses attention on the variables over which the organization and its employees have some control.

OTHER FORMS OF INCENTIVES:

Apart from the above mentioned incentive plans; there are also other forms of incentives, especially for the white collared workers. They are briefly discussed below.

- **Employee Stock Option Plan:**

  This is popularly known as ESOP. This is a form of incentive where the employees are allotted the company share at a price below the market price. When the company achieve better results, the market price of its shares and the value of the employees' shareholding rise.

  This form of incentive plan is relatively new in India and is becoming popular of late. IT is motivating to the employee, as (it enhances a sense of belongingness to the organization) shareholders are the owners of the organization.

- **Profit Sharing:**

  Prof. Seager defines profit sharing as "an arrangement by which employees receive a share, fixed in advance of the profits". Profit sharing usually involves the determination of an organization profits at the end of the fiscal, year and the distribution of a percentage of the profits to the workers qualified to share in the earnings. The main objectives of profits sharing are to create unity of interest and the spirit of co-operation.

  The theory behind profit sharing is that management should feel its workers will fulfill their responsibilities more diligently if they realize that their efforts may result in higher profits which will be returned to the workers through profit sharing.

  In India this incentive scheme is not well received by both the management and the workers. Committee appointed by the Govt. of India suggested profit sharing as a method of ensuring industrial peace and a step towards workers' participation in management and also suggested that 50% of the profit be shared among the workers.

  Both the employers and the trade unions rejected this. The trade unions prefer bonus to profits sharing as bonus is payable irrespective of profit or loss under the Bonus Act 1965.

- **Fringe Benefits:**

  ILO describes fringe benefits as wages are often augmented by special cash benefits, by the provision of medical and other services or by payment in kind that form part of the cost for expenditure on the goods in services.

In addition workers commonly receive such benefits as holidays with pay low cost meals, low rent housing etc. such additions to the wage proper are sometimes referred to as fringe benefits.

Fringe benefits involve a labour cost for the employer and are not meant directly to improve efficiency. These add to the workers standard of living. Hence benefits may be statutory or voluntary.

They improve motivation and morale of workers by satisfying their needs and develops a sense of belonging and loyalty among workers. They also improve the public image of the organization.

IMPORTANT QUESTIONS IN UNIT - V FROM PREVIOUS QUESTION PAPERS

1. Explain the various types of values. Discuss each of these citing suitable examples. [15M] April – 2015 Set 1
2. Critically evaluate different methods of merit rating. [15M] April – 2015 Set 1
3. Define Human resource management. What are its elements and what is its significance to organizational development? [8M] May/June – 2015 Set 1
4. Explain different methods of merit rating. [7M] May/June – 2015 Set 1
5. What are the key functions of a human resource manager? [8M] May/June – 2015 Set 2
6. Define job evaluation and narrate the various steps involved for evaluating the jobs. [7M] May/June – 2015 Set 2
7. What are the objectives and activities associated with man power planning? [8M] May/June – 2015 Set 3
8. Define wage incentive plans. What are its objectives and drawbacks? [7M] May/June – 2015 Set 3
9. Differentiate personnel and industrial relations from Human Resource Management. [7M] May/June – 2015 Set 4
10. Explain the following concepts with appropriate examples
    i) Job description ii) Job specification [8M] May/June – 2015 Set 4
11. Define 'Job evaluation' and narrate the various steps involved for evaluating jobs. [8M] Dec – 2015 Set 1
12. What is profit sharing? [4M] April - 2016 set 1
13. Why an employee must be rated? State and explain different methods of employee rating. [8M] April - 2016 set 1
14. Discuss the fundamental requirements of good financial wage incentive system. [8M] April - 2016 set 1
15. What is incentive? How it helps to improve production? [4M] April - 2016 set 2
16. What are the objectives and functions of trade union? [8M] April - 2016 set 2
17. Explain Rowan plan of wage rating. [8M] April - 2016 set 2
18. State few non-financial incentives offered to the employees in a manufacturing industry. [4M] April - 2016 set 3
19. Explain the functions of personnel management. [8M] April - 2016 set 3
20. State the need and types of Job-evaluation. [8M] April - 2016 set 3
21. State the difference between merit rating and job evaluation. [4M] April - 2016 set 4

22. Why is it important to manage human resource in an organization? Discuss. [8M] April - 2016 set 4
23. Explain any one type of wage incentive plan that you think will improve the productivity of a continuous production industry. [8M] April - 2016 set 4
24. What are the benefits of 'job evaluation'? [7M] Nov/Dec 2016 set 1
25. How can HR manager help in maintaining cordial relations between trade unions and management? [8M] Nov/Dec 2016 set 1
26. What is merit rating and what are its objectives [3M] Nov/Dec 2016 set 1
27. State and explain the functions of personal management. [9M] Nov/Dec 2016 set 1
28. What are the main benefits and limits of job evaluation? [7M] Nov/Dec 2016 set 1
29. Explain the difference between job evaluation and merit rating [8M] April - 2017 set 1
30. What are the principles of human resource management? [7M] April - 2017 set 1
31. What do you mean by human resource management? [4M] April - 2017 set 1
32. Define personnel management. Enumerate its importance in business organization. Also state its characteristics. [8M] April - 2017 set 1
33. Enumerate various steps involved in job evaluation procedure. [8M] April - 2017 set 1
34. What are the functions of personnel management? [4M] April - 2017 set 2
35. State and describe the principles of personnel management briefly. [8M] April - 2017 set 2
36. Briefly explain the job evaluation methods with merits and demerits. [8M] April - 2017 set 2
37. Briefly discuss about wage incentive plans. [4M] April - 2017 set 3
38. Describe the important functions of personnel management. [8M] April - 2017 set 3
39. How is job analysis different from job description? What are the uses of it? [8M] April - 2017 set 3
40. How a merit rating is given for job evaluation? [4M] April - 2017 set 4
41. Define personnel management. State its characteristics. [8M] April - 2017 set 4
42. What is job evaluation? What objectives can be served from scientific job evaluation studies? [8M] April - 2017 set 4
43. What is job evaluation? What objectives can be served from scientific job evaluation studies? [7M] Nov - 2017 set 1
44. Why an employee must be rated? State and explain different methods of employee rating. [8M] Nov - 2017 set 1
45. What are the objectives of human resource management? [4M] Nov - 2017 set 1
46. What are the functions of a personnel manager? [8M] Nov - 2017 set 1
47. What do you understand by merit rating? List out its advantages and disadvantages.

[8M] Nov - 2017 set 1

48. What are the functions of personnel management? [4M] April - 2018 set 1

49. Define HRM? Explain its elements and significance to organizational development.

[8M] April - 2018 set 1

50. What is personnel management? What are its features and functions? [8M] April - 2018 set 1

51. Explain the job evaluation techniques? [3M] April - 2018 set 2

52. Briefly explain various wage intensive schemes? [8M] April - 2018 set 2

53. Define merit rating. Discuss the objectives, advantages and disadvantages of merit rating.

[8M] April - 2018 set 2

54. Explain job analysis techniques? [3M] April - 2018 set 3

55. What is the importance of industrial relations for the success of an organization? Explain.

[8M] April - 2018 set 3

56. Define wage incentive plans. What are its objectives and drawbacks? [8M] April - 2018 set 3

57. What are the elements of HRM? [4M] April - 2018 set 4

58. Describe the functions of human resource management? [8M] April - 2018 set 4

59. Differentiate personnel and industrial relations from HRM? [8M] April - 2018 set 4

60. Write short notes on Job analysis. [4M] Nov - 2018 Set 1

61. Define HRM. Explain its elements and significance to organizational development.[7M] Nov - 2018 Set 1

62. What is personnel management? What are its features and functions? [7M] Nov - 2018 Set 1

63. Describe the general structure for double sampling plan. What are their advantages and disadvantages?

[15M] Nov - 2018 Set 1

64. Define man power planning? What are the characteristics and basis for man power planning?

65. Explain the qualities and qualifications necessary for a good personnel manager?

66. Define and explain the term industrial relations?

67. Define the term job evaluation? Explain the process of job evaluation?

68. Define job analysis? Explain its objectives and components?

UNIT - 6

VALUE ANALYSIS/VALUE ENGINEERING

SYLLABUS:

VALUE ANALYSIS: Value engineering, implementation procedure, enterprise resource planning and supply chain management.

INTRODUCTION

Value Analysis is one of the major techniques of cost reduction and control. It is a disciplined approach which ensures the necessary functions for the minimum cost without diminishing quality, reliability, performance and appearance.

It is a creative approach to eliminate the unnecessary costs which add neither to quality nor to the appearance of the product. It is a systematic application of techniques to identify the functions of a product or a component and to provide the desired function at the lowest total cost.

These are the days of providing the customer with really best quality products at least cost which is possible through value analysis which proves wrong rightly "Best and Cheap" or "Best is never cheap" or "Cheap is Costly".

What is Value Analysis?

Before understanding the meaning of phrase "value analysis" or "value engineering", let us know about value. 'Value' is one of those terms having good many connotations and even contradictory definitions.

'Value' is a word that is very often used by individuals without being clearly understood. Forget about common people. Even different departments of the same organisation have different opinions of the 'value' of the product that the company manufactures.

The designer equates value with reliability; purchase people with price paid for them; production personnel with that of cost from the angle of manufacture; sales people with what customer is willing to pay.

VALUE ANALYSIS AND VALUE ENGINEERING:

'VA' and 'VE' are closely related terms so much so that many people use them interchangeably. Though the philosophy understanding the two is the same the identification of unnecessary costs yet they are different. The difference lies in the time and stage at which the technique is applied.

"Value Analysis" is the application of a set of techniques to an existing product with a view to improve its value. Thus, it is remedial process. "Value Engineering" is the application of exactly the same set of

techniques to a new product at the design stage project concept or preliminary design when no hardware exists to ensure that bad features not added. Thus, it is a 'preventive' measure. In that sense, 'VE' is fundamental and VA is collateral because 'prevention is better than cure."

VA/VE APPROACH & MAIN STEPS

According to the principles of "*Techniques of Value Analysis Engineering*" there are different phases of VA/VE:

- Exhaustive accumulation of information and identification and improvement of assumptions.
- Penetrating analysis. What senses of direction does this informative provide us with? What specific problems will, when solved, bring important cost benefits?
- Creative mental activity, in which all judgement is temporarily deferred to form the roots of a variety of different solutions to each of the specific problems developed in the preceding analysis.
- Judgment-type mental activity, in which what results from creative thought is searched for ideas roots to minimize disadvantages and maximize advantages sufficiently to meet the need for cost and/or operation improvement.

During the information phase, the project and its requirements are analyzed, and then the function analysis studies the possible room for improvement. In the creative stage ideas to increase performances are developed: from the resulting list of ideas only a short set is evaluated in order to find the ones with best potential to reach the goal. The following step is development of alternatives and their presentation to decision makers and, eventually, implementation.

VA/VE tools are extremely powerful and fundamental to reach objectives such as decreasing costs, improving quality and shortening time-to-market.

TYPES OF VALUE ANALYSIS

a. Cost Value
b. Use/Functional Value
c. Esteem Value
d. Exchange Value

⇒ **Cost Value:** It is the cost of manufacturing a product or a component. It is the measure of sum of all costs incurred in producing the product. The cost value therefore is the sum of raw material cost, labour cost, tool cost and overheads expended to produce the product.

⇒ **Use/Functional Value:** It considers the work done, functions performed or services rendered by a product/component. It is the measure of properties, qualities and features which make the product accomplish a use or service. It is the price paid by the buyer (customers view) or the cost incurred by the

manufacturer (manufacturers view) in order to ensure that the product performs its intended functions efficiently.

⇒ **Esteem Value:** It is the measure of properties, features, attractiveness, qualities, fancy, packing etc., which increase sales appeal or which attracts persons and creates in them a desire to possess the product.

⇒ **Exchange Value:** A product is said to possess exchange value if the same (because its qualities usefulness) can be exchanged for another product or money. Or in other words exchange value refers to the price that customer will offer for the product, the price being dependent upon the satisfaction which he derives from the product.

OBJECTIVES OF VALUE ANALYSIS

1. Saving in Cost
2. Quality Promotion
3. Import Substitution
4. Maximization of the value of product
5. Elimination of unnecessary processes
6. New products and product design
7. Company Image

- **Saving in Cost:** Cost reduction is, without doubt, the primary objective of any business venture. The overall cost of an end product may be reduction by obtaining raw materials or components at higher prices if they reduce the manufacturing cost by a larger margin than the extra prices paid for the raw materials. For instance a manufacturer who was using for fabrication a particular welding rod for many years was persuaded to try another rod superior in quality, but 15 percent higher in price. in the trails it was concluded that the new rod was easier to work with, gave stronger welded joints and made it possible to obtain more welded work to be completed in a given period of time. in actual practice, it was found that despite its higher price, the new welding rod gave an overall net saving of about 10 percent. The manufacturer rightly took the decision to go for the rod.
- **Quality Promotion**: Value engineering also aims at solving quality problems. Repeated failure or rejection of a part invokes the analysis to be made on it. Reduced rejections result in increased productability, better serviceability. Improved marketability and better margin of profit. Providing a competitive and quality helps in export promotion.
- **Import Substitution:-**If we manufacturer a product in our country and the cost is little more than that of the imported from other country, we can say that the imported product is more beneficial to us. But in reality, it is beneficial as person-wise but as country wise there will be a great loss of foreign exchange. So we would give preference to the product made in our country over the imported one.
- **Maximization of the value of product:-**By the way of either reducing the cost, or adding to the quality of the product, value analysis tends to add to the value of the product. A higher-valued product always stands a better chance of being sold in the markets.

- **Elimination of Unnecessary costs:**-In many cases it has been observes that the industrial units are using excessive number of processes that are actually required.
- **New products & Product design:**-It is a technique generally undertaken for new products. By the way of this technique, such product design are found which if adopted may lead to the increased sales, and virtually increased profits for the business.
- **Company Image:**-All the above factors, along with others will lead to the improved goodwill of the business in the market. The benefits of higher goodwill generally continue to be enjoyed for long, rather than short period of time. Furthermore, a better-imaged company, in the present business environment, can spread its wings to not only the domestic country but also to the whole world.

VALUE ANALYSIS VERSUS OTHER CONVENTIONAL APPROACHES:

Speaking in terms of "cost reduction" value analysis is an effective tool of cost reduction which differs from established conventional approaches such as industrial engineering, production engineering, methods engineering and the like.

The "traditional" or "conventional" approaches differ from this non- conventional or modern technique of VA as under:

1. Traditional approaches concern "post-production" stage but V.A. can be the 'pre-production' as well as "post production stage" technique.
2. Traditional approaches are "methods concerned". They accept the drawing of the part "as is" and, therefore, set to improve the part through analysis of manufacturing methods, machines, materials, tools, jigs and fixtures and the like.

   On the other hand, 'VA' does not accept the designed product and its components "as is" but advocates cost reduction through identification of the function and subsequent redesign of the product so as to make it perform its functions at the lowest possible cost.

   'VA', therefore, challenges the very design specifications, design requirements and the design itself.
3. Traditional methods are mere "cost centered" while VA, in addition to cost improvement, usually seeks to improve quality, reliability, maintainability, safety, performance and alluring features.
4. VA is more potent than traditional cost reduction techniques. Instances can be brought to surface to demonstrate that VA can remove ten to twenty percent of cost after the traditional methods of cost reduction have applied.

   Award of warning is essential at this stage, lnspite of VA's better potential and greater effectiveness, it is not a substitute nor is it intended to replace effective cost reduction techniques which have been in use for many years and have proved effective and valuable in their areas of application. What can be said is that VA can augment or strengthen the process of cost reduction and quality improvement.

IMPLEMENTATION PROCEDURE/PHASES OF VALUE ANALYSIS:

The phases of value analysis are:

1. Phase of Origination
2. Phase of Information
3. Phase of Innovation
4. Phase of Evaluation
5. Phase of Choice
6. Phase of Implementation
7. Phase of Review

1. Phase of Origination: In the first phase, a value analysis study team is constituted. The project is selected and clearly defined. The team examines in detail the product and its components to understand thoroughly their nature.

2. Phase of Information: After familiarisation, a functional analysis is carried out to determine the functions and uses of the product and its components. The cost and importance of each function are identified. A value index is calculated on the basis of cost benefit ratio for each function. A list is being prepared in which the items of functions are arranged in decreasing order of value.

3. Phase of Innovation: This is the creative phase concerned with the generation of new alternatives to replace or removing the existing ones.

4. Phase of Evaluation: Each and every alternative is analysed and the most promising alternatives are selected. These alternatives are further examined for economic and technical feasibility.

The alternatives finally selected must be capable of performances the desired functions satisfactorily. These must meet the standards of accuracy, reliability, safety, maintenance and repairs, environmental effects and so on.

5. Phase of Choice: In this phase, report is prepared. This report contains a summary of the study, conclusions and specific proposals. The decision makers choose the alternative. The programs and action places are then developed to implement the chosen alternative.

6. Phase of Implementation: The chosen alternative is put to the actual use with the help of the programs and action plans so developed in advance.

7. Phase of Review: The progress of analysis changes in continuously monitored and followed up in order to provide assistance, to clarify any misconceptions and to ensure that the desired results are achieved.

MERITS OF VALUE ANALYSIS:

Value analysis is really a very valuable technique of cost reduction and quality improvement. The specific merits of are as follows:

1. Improvement in Product Design: It leads to improvements in the product design so that more useful products are given shape. Now in case of ball points, we do not have clogging, there is easy and even flow of ink and rubber pad is surrounding that reduces figures fatigue.

2. High Quality is maintained: High quality implies higher value. Thus, dry cells were leaking; now they are leak proof; they are pen size with same power. Latest is that they are rechargeable.

3. Elimination of Wastage: Value analysis improves the overall efficiency by eliminating the wastages of various types. It was a problem to correct the mistakes. It was done by pasting a paper. Now, pens are there and liquid paper is developed which dries fast and can write back.

4. Savings in Costs: The main aim of value analysis is to cut the unwanted costs by retaining all the features of performance or even bettering the performance. Good deal of research and development has taken place. Now milk, oils, purees pulp can be packed in tetra packing presuming the qualities and the tetra pack is degradable unlike plastic packs.

5. Generation of New Ideas and Products: In case of took brushes, those in 1930's were flat and hard, over 60 to 70 years brushes have come making brushing teeth easy, cosy and dozy as it glides and massages gums.

6. Encourages Team-Spirit and Morale: Value analysis is a tool which is not handled by one, but groups or teams and an organisation itself is a team of personnel having specification. A product is the product of all team efforts. Therefore, it fosters team spirit and manures employee morale as they are pulling together for greater success.

7. Neglected Areas are brought under Focus: The organisational areas which need attention and improvement are brought under the spot-light and even the weakest gets a chance of getting stronger and more useful finally join's the main strain.

8. Qualification of Intangibles: The whole process of value analysis is an exercise of converting the intangibles to tangible for decision making purpose. It is really difficult to make decisions on the issues where the things are (variables) not quantifiable.

However, value analysis does it. The decision makers are provided with qualified data and on the basis of decisions are made. Such decisions are bound to be sound.

9. Wide Spectrum of Application: The principles and techniques of value analysis can be applied to all areas-man be purchasing, hardware, products, systems, procedures and so on.

10. Building and Improving Company Image: The company's status or image or personality is built up or improved to a great extent. Improvement in quality and reduction in cost means competitive product and good name in product market; it is a good pay master as sales and profits higher and labour market it enjoys reputation; it capital market, nobody hesitates to invest as it is a quality company.

LIMITATIONS OF VALUE ANALYSIS:

Like any other cost reduction technique, value analysis has its own limitations. The most common limitations are that the man-made excuses are the blocks in implementing these plans of value analysis.

The most common excuses given are:

a) Lack of motivation
b) Resistive to change
c) Inertia
d) Lack of knowledge and patience
e) Attitude of 'It will not work in India
f) We are very small or very big
g) This has been tried earlier and failed
h) The change is too big
i) 'Let competitors try before we try'
j) Difficulty of teams meeting or team meeting for getting consensus.

These limitations are man-made and can be over-come one the company divides to implement. However, they should be educated of the plus and minus points and the main beneficiaries are those that are to be told and they are to be taken into confidence.

ERP - ENTERPRISE RESOURCE PLANNING:

INTRODUCTION

Enterprise Resource Planning is used for business management systems which are designed to integrate the data sources and processes of an entire organization into a unified system**. A key element is the use of a single database to store data for the various system modules.**

ERP systems utilize components of both computer software and hardware. Traditionally the software is installed at the customer site, but many companies now offer hosted or 'cloud' ERP solutions to reduce the up-front and technical costs.

DEFINITIONS:

Enterprise Resource Planning An accounting oriented information system for identifying and planning the enterprise-wide resources to make ship and account for customer orders.

"An enterprise planning system is an integrated computer based application used to manage internal and external resources, including tangible assets, financial resources, material and human resources".

Enterprise resource planning (ERP) is business management software that allows an organization to use a system of integrated applications to manage the business. ERP software integrates all facets of an operation, including development, manufacturing, sales and marketing.

Enterprise Resource Planning (ERP) is defined as an Integrated Computer based planning technique used in Organizations and Enterprises for management and resource planning. Resources here mean both internal and external resources of an organization. Various resources of an organization can include financial resource, tangible resource, human resource and also various material requirements.

ERP can also be defined as an application and software architecture that facilitates Information flows between various business functions inside and outside of an organization. It consolidates business environment into a uniform system environment. Basically what ERP systems do is that it integrates and automates processes within an entire organization regardless of the organization's behaviour.

'ERP is a method for effective planning and control of all resources needed to take, make, ship and account for customer orders in a manufacturing, distribution or service company.'

SIGNIFICANCE OF ERP:

In today's environment ERP plays a significant role in the following things

- Reduction of lead-time
- On-time shipment
- Reduction in Cycle time
- Better customer satisfaction
- Improved supplier Performance
- Increased flexibility
- Reduction in quality Costs
- Improved Resource Utility

MODULES OF ERP:

Organizations are implementing Enterprise Resource Planning system to streamline their internal business process and for smooth flow of data between the different functional departments like inventory, purchase, production, accounts, etc. The different functional modules of the ERP software look after the respective functional department. Some of the functional modules in the ERP are as follows:

1. **Production Planning Module:** The Enterprise Resource Planning system has evolved from Material Resource Planning which was used for the manufacturing requirements of the companies. ERP is more robust software for production planning as it optimizes the utilization of the manufacturing capacity, material resources and the parts using production data and sales forecasting.

2. **Purchasing Module:** This module aids in streamlining the procurement of required raw materials. It is integrated with the inventory control and production planning modules and often with the supply chain management software. This module automates the process of identifying potential suppliers, supplier evaluation. It is used for automation and management of purchasing.
3. **Inventory Control Module:** This module aids in managing the company's resource inventory and the product inventory. It helps in handling the replenishment of the product and maintenance of the stock levels of the products. The inventory control module monitors the inventory stock present at the different locations like at the warehouse, office and stores. The module can manage the inventory of raw materials used for product planning. It enables the company to plan the future production and keep a stock of products which go below critical level.
4. **Sales Modules:** This module automates the sales tasks, customer orders, invoicing and shipping of products. It is integrated with the company's ecommerce websites and many vendors provide with online storefront as a part of this module. The sales department is an important area for the organization.
5. **Accounting and Finance Modules:** Accounting and finance are the core areas of an organization. This module interacts with the other functional modules to collect the financial data for the general ledger and other financial statements of the company.
6. **Human Resource Module:** This can be used as an independent module. It is used for integrating the recruitment process, payroll, training and the performance evaluation process. The module handles the history of the employee, tracks the employees laid off and aids in rehiring of the employees.
7. **Manufacturing Module:** This module includes product designing, bills of material, cost management, workflow, etc.
8. **Marketing Module:** The ERP marketing module supports lead generation and the promotional activities.

In simply ERP are used in various Industries and organizations like manufacturing, distribution, transportation, education, healthcare, banking and others. ERP delivers a single database that contains all data for the various software modules. It typically addresses areas such as:

1) **Manufacturing resource planning:** Engineering, bills of materials, scheduling, capacity, workflow management, quality control, cost management, manufacturing process, manufacturing projects and manufacturing flow.
2) **Supply chain management:** Order to cash, inventory, order entry, purchasing, product configuration, supply chain planning, supplier scheduling, inspection of goods, claim processing and commission calculation.
3) **Financial management:** General ledger, cash management, accounts payable, accounts receivable, fixed assets.
4) **Project management:** Billing, time and expense, performance units, activity management.
5) **Human resource management:** Human resources, payroll, training, time and attendance, roistering, benefits.

THE DRIVING FORCE BEHIND ERP:

There are two main driving forces behind Enterprise Resource Planning for a business organization.

- In a business sense, Enterprise Resource Planning ensures customer satisfaction, as it leads to business development that is development of new areas, new products and new services.

  Also, it allows businesses to face competition for implementing Enterprise Resource Planning, and it ensures efficient processes that push the company into top gear.

- In an IT sense: Most softwares does not meet business needs wholly and the legacy systems today are hard to maintain. In addition, outdated hardware and software is hard to maintain.

Hence, for the above reasons, Enterprise Resource Planning is necessary for management in today's business world. ERP is single software, which tackles problems such as material shortages, customer service, finances management, quality issues and inventory problems. An ERP system can be the dashboard of the modern era managers.

ADVANTAGES/ BENEFITS OF ENTERPRISE RESOURCE PLANNING (ERP):

(a) Business integration: The first and the most important advantage lie in the promotion of integration. The reason ERP packages are called integrated is the automatic data up gradation between related business components, since conventional company information systems were aimed at the optimization of independent business functions in business units, almost all were weak in terms of the communication and integration of information that transcended the different business functions in the case of large companies in particular, the timing of system structure and directives differs from each product and department / functions and sometimes they are disconnected.

For this reason, it has become an obstacle in the shift to new product and business classification. In the case of ERP packages the data of related business functions is also automatically updated at the time a transaction occurs. For this reason, one is able to grasp business details in real time, and carry out various types of management decisions in a timely manner based o that information.

(b) Flexibility: The second advantage of ERP packages is their flexibility. Diverse multi-functional environments such as language, currency, accounting standards and so on are covered in one system and functions that comprehensively managed multiple locations that span a company are packaged and can be implemented automatically. To cope with company globalization and system unification, this flexibility is essential, and one could say that it has major advantages, not simply for development and maintenance, but also in terms of management.

(c) Better analysis and planning capabilities: Yet another advantage is the boosting of planning type functions. By enabling the comprehensive and unified management of related business and its data, it becomes possible to fully utilize many types of decision support systems and stimulation systems. Furthermore, since it becomes possible to carry out flexibility and in real time the feeling and analysis of data from a variety of dimensions, one is able to give decision makers the information they want, thus enabling them to make better and informed decisions.

(d) Use of latest technology: The fourth advantage is the utilization of latest developments in information technology (IT). The ERP vendors were very quick to realize that in order to grow and to sustain that growth: they have to embrace the latest developments in the field of information technology. So they quickly adopted their systems to take advantages of the latest technologies like open systems, client server technology, internet/ intranet, computer aided acquisition and logistics support, electronic commerce etc. It is this quick adaptation to the latest changes in information technology that makes the

flexible adaptation to changes to future business environments possible. It is this flexibility that makes the incorporation of the latest technology possible during the system customization, maintenance and expansion phases.

(e) Reduced inventory and inventory carrying cost: The manufacturing nature of many ERP users makes the issue of process and material costs savings paramount. The main factor behind these savings is that implementation of the ERP system allows customers to obtain information on cost, revenues and margins, which allow it to better, manage its overall material cost structure. This ability to manage costs is best seen in savings that organizations can obtain in their inventory systems. Customers can perform a more complete inventory planning and status checking with the ERP system.

These checks and plans reveal existing surpluses or shortages in supplies. Improved planning and scheduling practices typically lead to inventory reductions to the order of 20 per cent or better. This provides not only a one time reduction in assets (cost of the material stocked), but also provides ongoing savings of the inventory carrying costs. The cost of carrying inventory includes not only interest but also the costs of warehousing, handling, obsolescence, insurance, taxes, damage and shrinkage.

(f) Reduced manpower cost: Improved manufacturing practices lead to fever shortages and interruptions and to less rework and overtime. Typical labor savings from a successful ERP system are a 10 per cent reduction in direct and indirect labor costs. By minimizing rush jobs and parts shortages, less time is needed for expediting, material handling, extra setups, disruptions and tracking splits lots odd jobs that have been set aside. Production supervisors have better visibility of required work and can adjust capacity or loads to meet schedules. Supervisors have more time for managing, directing and training people. Production personnel have more time to develop better methods and improve quality.

(g) Reduced material costs: Improves procurement practices lead to better vendor negotiations for prices, typically resulting in cost reductions of 5 per cent or better. Valid schedules permit purchasing people to focus on vendor negotiations and quality improvements rather than spending their time on shortages and getting material at premium prices. ERP systems provide negotiation information, such as projected material requirements by commodity group and vendor performance statistics. Giving suppliers better visibility of future requirements help them achieve efficiencies that can be passed on as lower material costs.

(h) Improves sales and customer service: Improved coordination of sales and production leads to better customer service and increased sales. Improvements in managing customer contacts, making and meeting delivery promises, and shorter order to ship lead times, lead to higher customer satisfaction, goodwill and repeat orders. Sales people can focus on selling instead of verifying or apologizing for late deliveries. In custom product environment, configurations can be quickly identified and prices, often by sales personnel or even the customer rather than the technical staff.

Taken together, these improvements in customer service can lead to fewer lost sales and actual increase in sales, typically 10 per cent or more. ERP systems also provide the ability to react to changes in demand and to diagnose delivery problems. Corrective actions can be taken early such as determining

shipment priorities, notifying customers of changes to promise delivery dates, or altering production schedules to satisfy demand.

(i) **Efficient financial management:** Improves collection procedures can reduce the number of days of outstanding receivables, thereby providing additional available cash. Underlying these improvements is fast, accurate invoice creation directly from shipment transactions, timely customer statements and follows through on delinquent accounts. Credit checking during order entry and improved handling of customer inquires further reduces the number of problem accounts. Improved credit management and receivable practices typically reduce the days of outstanding receivables by 18 per cent or better. Trade credit can also be maximized by taking advantage by supplier discounts and cash planning, and paying only those invoices with matching recipients. This can lead to lower requirements for cash-on-hand.

The benefits from ERP come in three different forms i.e. in the short-term, medium-term and long-term. When initially implemented, in a year of the organization going live with ERP, it helps in streamlining the operational areas such as purchase, production, inventory control, finance and accounts, maintenance, quality control, sales and distribution, etc. This benefit is in form of 'automating

SUPPLY CHAIN MANAGEMENT (SCM)

INTRODUCTION

If you go to a Supermarket and pick up a few items of the shelf from electronics and white goods or even clothes and look at the labels, chances are that you will find them having been manufactured in China or Mexico. The coffee pods you buy to use for your everyday use comes from Africa. Computers have been shipped out of South American Factories and Soft furnishings on the shelves are from India and Hong Kong.

Global markets are expanding beyond borders and re-defining the way demand and supplies are managed. Global companies are driven by markets across continents. In order to keep the cost of manufacturing down, they are forced to keep looking to set up production centres where cost of raw materials and labor is cheap. Sourcing of raw materials and vendors to supply the right quality, quantity and at right price calls for dynamic procurement strategy spanning across countries.

With the above scenario you find companies procuring materials globally from various vendors to supply raw materials to their factories situated in different continents. The finished goods out of these different factory locations then pass through different chains of distribution network involving warehouses, exports to different countries or local markets, distributors, retailers and finally to the end customer.

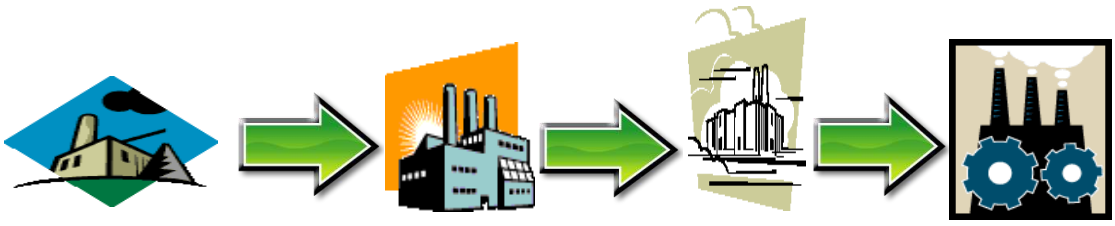
DEFINITIONS:

SCM is the management of a network of all business processes and activities involving procurement of raw materials, manufacturing and distribution management of Finished Goods. SCM is also called the art of management of providing the Right Product, At the Right Time, Right Place and at the Right Cost to the Customer.

Supply Chain definition is the movement of materials as they flow from their source to the end customer. Supply Chain includes purchasing, manufacturing, warehousing, transportation, customer service; demand planning, supply planning and Supply Chain management. It is made up of the people, activities, information and resources involved in moving a product from its supplier to customer.

The management of the movement of goods and flow of information between an organization and its suppliers and customers, to achieve strategic advantage. Supply chain management covers the processes of managing materials, physical distribution, purchasing, information, and logistics.

Example of a Supply Chain



Raw materials **Manufacturer** **Distribution** **Customer**

SUPPLY CHAIN BENEFITS:

Experience shows that the benefits of a well designed and implemented Supply Chain Management strategy is substantial. Successfully implemented projects have provided benefits such as:

- Reduction of Transportation, Warehousing, and Distribution Costs
- Lean Processing from Supplier to Customer
- Reduced Direct and Indirect Labor Costs
- Optimized Stock Levels
- Increased Material Flow Velocity
- Accurate Job Costing and Scheduling
- Streamlined Purchasing Control
- Increased Decision Making Speed and Responsiveness to Demand Change
- Increased Customer Service
- Increased Inventory Availability, Customer Order Fill Rates, Accuracies and Services
- Reduced Operations Support Costs
- Reduced Inventory Carrying Costs
- Improved Productivity of Procurement Operations
- Improved Quality of Products and Service

SUPPLY CHAIN CHALLENGES:

- Customer Trading Rules
- Supplier Trading Rules
- Inventory Service Level Balance

- Multiple Sales Channels
- New Geographic Markets
- New Product Offerings
- Postponement
- Supplier Proliferation
- Customization and Personalization
- Uninterrupted Materials Visibility
- Transportation Shortages
- Regulatory Compliance
- Fuel Volatility