INTERMEDIATE

GROUP - I
PAPER 9

OPERATION MANAGEMENT AND INFORMATION SYSTEMS

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SYLLABUS

PAPER 9: OPERATION MANAGEMENT AND INFORMATION SYSTEMS

(ONE PAPER: 3 HOURS: 100 MARKS)

Section A: Operation Management (50 marks)

1. Overview of Production Process

- Fabrication process
- Metal working process – Forming, Heat Treatment, Welding, Surface treatment etc.
- Machining process
- Class of machine – Lathes, Drilling, Grinding, Milling, Plaining, Shaping, Slotting etc.
- Special purpose machine – Special Grinding, Hobbing, Honing, Cutting Tools, Jigs and Fixtures etc.
- Pump, Motor, Transformer, Electrical drives,
- Classification of industries based on production process
- Technological aspects of different production process like power, pollution control, recovery process,
- Plant layout , Material handling system etc

2. Production Planning & Productivity Management

- Time Study, Work Study, Method Study, Job Evaluation.
- Production Planning and Control-Introduction.
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- Capacity Planning and Utilization.
- Process Planning,
- Project Planning.
- Progressing and Follow-Up.
- Dispatching.
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- Economic Batch Production
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Operation Management

STUDY NOTE - 1

Overview of Production Process

1.0 Fabrication Process

Fabrication is the process of forming, casting, machining and welding of metals.

A fabricating process modifies the physical characteristics of materials with the help of certain labour or machine operations. It is generally applied in metal working industries. The fabricating process involves changing the shape of materials and connecting the parts. Fabrication work involves several operations like forging, gas welding, flame-cutting, etc.

Classification of Fabrication processes:

(A) **Fabrication process concerning Iron Smelting:** Metals are widely used for fabrication purposes in most of the modern industries. Various metals like iron have-to be smelted to get them in virgin form. Iron is obtained in free state as oxide and it is smelted in a Blast Furnace with the help of coke and limestone.

(B) **Fabrication Process concerning Making of Steel:** Steel making involves re-melting the pig iron and processing the molten iron to reduce the carbon content. Several other metals are then added to give physical characteristics to the iron. This process is used in manufacturing high grade alloy steel because of the improved control.

(C) **Fabrication Process concerning Rolling of Steel:** In this process, liquid steel is cast into ingots. These rectangular pyramids are then rolled into blooms which square section lengths of steel. Blooms are further heated and rolled into billets of smaller cross-section, which are then converted into various fabricated lengths like beams, angles, rods, flats, sheets, plates, etc.

(D) **Fabrication of Steel:** The fabrication requirements are designed based and depends upon the complexity of the process. It is done when steel materials are to be shaped in different forms.

Metal Working Processes:

Metal working processes involve operations on metals like cast iron, steel, brass, bronze, aluminium, etc, with the help of machine tools like lathe, shaper, miller, grinder, planner, etc.

The following are the metal working processes:

- Finishing, plating, honing, galvanizing, anodising.
- Forming, casting, forging, hot-rolling, extruding.
- Heat treatment, hardening, tempering, annealing, normalising.
- Joining, welding, soldering, brazing, riveting.
- Machining, milling, plaining, shaping, grinding.

Metal working processes can be described as under:

Casting: A casting may be defined as a molten material that has been poured into a prepared cavity and allowed to solidify. Casting may be classified as:

Sand Casting: It is used mainly for steel and iron and it can also be used for brass, aluminium, bronze, copper etc. and relatively large amount of metal is to be removed.

Features of Sand Casting:

- Clay and water act as a bond.
- Compressed moist sand is used.
- Less costly.
- More machining of finished goods is required.
- More weight.

There are two methods of sand casting:

Green Sand Moulding and Dry Sand Moulding.

Green sand Moulding utilises a mould made of compressed moist sand. This method is not suitable for large and heavy castings. In case of Dry sand Casting, the mould surfaces are given refractory coating and are dried before the mould is closed for pouring. This method is useful for large and heavy castings.

Centrifugal Casting: The molten metal is poured into a hollow cylindrical mould, which is spinning and the centrifugal force causes the liquid metal to flow to the outside of the mould and to remain there. Then it is allowed to cool.

Die Casting: The dies are expensive but the advantage is that no finish machining is required in many cases. This is limited to low melting point alloys.

Investment Casting: Machining the part made out of an alloy is very difficult and in such cases, the investment casting is used.

Permanent Mould Casting: This is developed to avoid the above disadvantage. The advantages are smoother finish, higher mechanical properties, good dimensional uniformity and ease of adaptability to automatic high production. But this is having high initial cost of tooling and the size of casting is also limited by the mould making equipment.

Plaster Mould Casting: Only one casting is made and then mould is destroyed. The advantages of plaster are the superior surface finish, improved metal characteristics and good dimensional accuracy. But the disadvantage is that the mould is destroyed each time.

Forming: Forming processes are those which accomplish the rough sizing or shaping of manufactured articles. Any cutting tool which produces a desired contour on the work piece comes under forming process.

Heat Treatment: It is a process of heating and cooling metals in order to obtain certain desired properties. Then the right combination of hardness and toughness is achieved for enabling the cutting tools to be able to successfully machine other metals. In addition to hardness and toughness, this process will improve heat and corrosion resistance and relieve stresses. The various types of heat treatment processes are briefly discussed below:

- ***Annealing:*** It refers to the heating and cooling operations which are usually applied to induce softening. Annealing softens overly hard, overly brittle part, through heating, short of critical point, followed by gradual cooling. Thus it relieves further the brittleness introduced by “hardening” and reduces metal electricity slightly.

- ***Case Hardening:*** This process involves two operations. The first is a carburizing process where carbon is added to the outer surface by heating low carbon steel. The second operation is heat treatment of the carburized parts so that the outer surface becomes hard.

- ***Hardening Steel:*** Hardening is the process of heating a metal to the decalescence point, soaking it for a considerable time to allow thorough penetration of the heat in the metal structure and then suddenly quenching it in cold liquid.
- ***Normalising:*** Normalising is the process, in which parts are allowed to cool in still air at room temperature.
- ***Quenching:*** Quenching is the process of rapidly cooling the metal from a high temperature. Rapid cooling is required for obtaining high strength and hardness and the purpose is to harden steel so that it can withstand wear and tear.
- ***Tempering:*** Heat treatment should relieve stress as stated above. But after quenching, the metal is hard and brittle. It requires reheating. Tempering is the process of reheating which will reduce the brittleness and soften the steel.

Welding Process:

Welding is a process of joining similar metals by the application of heat, with or without application of pressure and addition of filler material.

"Welding consists of fusing metals together while they are in the plastic or molten state." Gas and Electric arc are used for the purpose of heat. Electrodes are used for filling in and reinforcement. There are 8 welding processes as mentioned below:

- Arc welding
- Brazing
- Flow welding
- Forge welding
- Gas welding
- Induction welding
- Resistance welding
- Thermit welding

Surface Treatment:

Surface-treating processes are chemical or mechanical in nature and alter the surface characteristics of the metal.

Eleven Types of surface treatment are briefly described below:

- ***Anodizing:*** It is an electro-chemical process which gives a slight anticorrosion protection and improves the appearance of the product. Unlike other types of surface treatment, this does not increase the dimensions of the object. This gives a better finish. It is used in case of utensils, household appliances etc.
- ***Enamelling:*** It is a process that bakes on a white, brittle protection finish.
- ***Galvanising:*** It is a hot-dip process which provides an anti-rust zinc coating. Zinc is used for this purpose. This makes the surface of the metal anti-corrosive and gives a better finish.

- ***Honing:*** It is an abrading operation for hole finishing done by a tool fitted with a bonded abrasive stone.
- ***Lapping:*** It is a surface smoothing operation by hand or machine.
- ***Painting:*** It will yield protective coating and better appearance.
- ***Plastic coating:*** This process is more durable than painting.
- ***Plating:*** It is an electrolytic process. This can be done with the help of silver, chromium, cadmium, nickel and copper. Plating provides anticorrosive finish.
- ***Shot Blasting:*** Small shots usually in the form of iron balls are made to blast on the metal required for making it resistance to wear and tear, remove the stresses and hardness.
- ***Shot penning:*** It is air blasting the small shots against the metal surface in order to increase the hardness of surface.
- ***Tumbling:*** Castings are tumbled in a tumbling barrel together with an abrasive substance. The friction created in this way will clean the surface.

Other surface treating processes may be such as:

- Buffing etc.
- Polishing,
- Power brushing,
- Sandblasting,
- Washing,
- Waxing

1.1 Machining Process

Machinability is described as the case with which metal can be removed. The various machining processes are briefly described below:

- ***Blanking:*** In this process also "punch and die" is used for making domestic utensils or machine components. It produces necessary depressions and cut-outs.
- ***Boring:*** In this case, the work piece is held by a fixture and a rotary cutter is used for boring a hole in a cylindrical shape. The existing hole may be enlarged. The boring may be straight or tapered.
- ***Broaching:*** The broach is made up of a bar of suitable length with a series of cutting edges on its surface. These cutting edges are arranged progressively higher from the starting to the end and hence each successive tooth removes an additional amount of material. This is done with the help of a cutter known as "broacher". This process also produces slots and gear teeth.
- ***Die Cutting:*** It is of two types 'punching' and 'Blanking' type. In the punching die, the metal removed by the die is a scrap, leaving a hole in the work piece. The blanking die shears through the work piece and the metal removed by the die is the finished work piece.

- ***Drilling:*** The work piece is clamped on the work table and drill is fed into for generating a hole and enlarging an existing hole. It is the operation of making a uniform hole through the work piece with the help of a cutter known as 'drill bit'. The hole can be made by rotating the job also.
- ***Facing:*** Facing is an operation of producing a smooth flat surface on the face of the job.
- ***Flame cutting or gas cutting:*** It employs an oxyacetylene torch, which may be directed either by hand or pantograph and cuts up to 40inch.thickness. Flame cutting is an inexpensive method. Gas cutting is the process of heating the metal to red hot temperature and then oxidising it by an oxygen jet. The metal oxide is removed by the pressure of the oxygen jet. Oxyacetylene flame is used for heating. A jet of high pressure oxygen is used to effect the cutting.
- ***Grinding:*** It is a process of removing the metal form and finishing the surface of a metal object by a grinder with the help of abrasive wheel rotating at high speed. It produces smooth and accurate surface finely finished at a quicker rate. It is suitable for repetitive jobs and for mass production. Grinding may be done on the job of any size or shape and on internal as well as external surfaces. It ensures high dimensional accuracy and surface finish. Normally the grinding follows some other machining like turning and milling etc.
- ***Milling:*** Milling is a method of removing metal with a milling cutter in order to produce specific shape. The function of milling is to dress a flat or other surface to a fine finish, surface forming of gear teeth, keyways etc.
- ***Parting:*** In this process, a parting tool or hack-saw is used for cutting off a part from the job.
- ***Plaining and Shaping:*** In shaping, the tool is reciprocated while the work piece moves straight forward at each stroke. In Plaining, the work piece reciprocates while the tool is moved for each new stroke. The shaper takes small work pieces and the planer takes larger work pieces.
- ***Punching:*** It produces cut-outs or perforations on plate surface e.g. holes in washer and slots in channels with the help of combination tool known as "punch and die".
- ***Reaming:*** The main purpose of reaming is to smooth the hole. In this process, a multiple point cutting tool called 'Reamer' is used.
- ***Sawing:*** Sawing is a cutting operation done by saw. Common types are Hacksaw, Circular saw and Band saw.
- ***Screw cutting:*** It is a process of cutting screw threads on the outside surface of a job with the help of a multiple point cutting tool known as 'Die'.
- ***Slotting:*** This process is used to produce the slots on the job.
- ***Taper Turning:*** After turning, it produces conical shape instead of cylindrical shape.
- ***Tapping:*** In this process, a multiple cutting tool called "Tap" is used for making threads on the inside surface of a hole.
- ***Turning:*** The work piece mounted on the lathe rotates at high speed above its axis. The path of the tool is parallel to the axis and the cutter is applied to the work piece as it turns thus chipping away the metal. Then a cylindrical external surface is formed. It is the operation of cutting and removing material from the surface of the job.

1.2 Class of Machines

Machine Tool: It is a power driven mechanical appliance or device used for removing metal from surfaces of jobs to give them the proper shape, size and other characteristics.

Classes of Machine Tools:

Machine Tools are now so numerous in type that they do not admit of any fixed classification. One possible classification is under two groups, namely

(1) General purpose or Standard Machine Tools, (2) Special Purpose Machine Tools.

The General Purpose or Standard Machine Tools form the most essential part of the equipment of a workshop. They are called Standard Machine Tools in the sense that they are very common and essential and a list of most important Machine Tools used in a workshop will invariably include these machines.

Many of them are suitable for many different types of operations. A lathe, which is the most important machine belonging to this group, can be employed for the general purposes of turning (producing cylindrical surfaces on a job), drilling (making a hole), screw cutting, producing flat surfaces, cutting teeth on a gear, cutting cylindrical holes in job, etc.

A special purpose Machine Tool performs only a limited number of specialised operations with great speed and precision. It does the same job as can be done by some General Purpose Machine, but it supersedes the latter on account of its high speed and accuracy. As for example, boring operation can be done on a lathe but the same operation can be done with greater speed and efficiency on a Boring Machine which has been developed for doing mainly the operation of boring.

The General Purpose Machine has great adaptability, but on account of the present day need for high-speed production of parts of great accuracy, Special Purpose Machines have been developed by sacrificing adaptability to specialisation.

Multi-purpose and Single-purpose Machine Tools:

Machine Tools are sometimes classified under Multi-purpose and Single-purpose machines.

A Multi-purpose Machine Tool is capable of doing a number of different types of operation. A Centre Lathe, a Milling Machine, a Grinding Machine, etc. are examples, of Multi-purpose Machines.

A Single-purpose Machine is one that is capable of doing only one particular kind of operation, but is not restricted to one particular job. As for example, a Shell Turning Lathe is designed specially for shell turning and is not adopted for general Lathe work. A Hobbing Machine, a Honing Machine, etc. are other examples of Single-purpose Machines.

Although a Single-purpose Machine has restricted field of use, it can do the particular operation for which it is employed at great speed and with a high degree of accuracy. When a large number of interchangeable parts are to be quickly produced, Special-purpose Machines are of great importance.

General Purpose or Standard Machine Tools:

The following are some General Purpose Machine Tools employed to do various operations:

- ***Drilling Machines-*** These Machines are used for drilling holes of different diameters in vertical or inclined directions.

- ***Grinding Machines -*** Grinding Machines are used for machining parts having cylindrical and tapered surfaces, for grinding internal surfaces and flat surfaces and for grinding slender bars and delicate parts.
- ***Lathes (Centre or Engine Lathe) -*** The operations performed on Lathes normally are Turning, Boring and Screw-cutting. Over and above these normal operations a Lathe can be adapted for the operations of Milling, Drilling, Slotting, Grinding, Gear and Rack Cutting, Lapping, Facing, Reaming, Polishing, Knurling, Tapping and Parting off.
- ***Milling Machines -*** These Machines are employed for producing plain and irregular surfaces, cutting slots by using special tools, cutting threads on dies, worms and screws and for gear-cutting.
- ***Plaining Machines -*** These Machines are used for machining flat surfaces and cutting Key-ways on larger jobs.
- ***Shaping Machines -*** The operations performed on Shaping Machines are machining of flat surfaces, cutting of Key-ways and T-slots on jobs not exceeding 12 inches in length.

1.3 Special Purpose Machines

Honing Machine: Honing, lapping and super-finishing equipment are used to improve surface finish or geometry to tight tolerances. Honing machines use small, bonded abrasive stones or super abrasive sticks mounted in a fixture that rotates and reciprocates when applied to the surface or bore being finished. Honing is used to correct the geometry and alignment of holes and to produce the surface required for the application. Honing is final finishing operation conducted on a surface, typically of an inside cylinder (bore), for example automobile engine cylinder. Abrasive stones are used to remove minute amounts of material in order to tighten the tolerance on cylindricity.

Honing is a surface finish operation, not a gross geometry-modifying operation. Honing Holders apply a slight, uniform, pressure using a number of abrasive sticks (Honing Sticks) that wipe over the entire surface to be honed thus removing material from the surface. Honing is the final process used in the machining cylinder bores, either during manufacture or in re-sizing (re-boring). Honing is used as a process to both remove the final amount of metal to get a cylinder bore to within the required size limits, and to put a surface on the cylinder bore which will give good life span, and aid lubrication and oil consumption characteristics in use.

Honing is not only carried out on cylinder bores for internal combustion engines but on compressors, hydraulics components and probably dozens of other applications.

Other Special Purpose Machine Tools:

The following list includes some of the most important Special Purpose Machines Tools:

- ***Boring Machines -*** These machines are used mainly for boring operations. By using Special Tools they may be adapted to facing the end of work and cutting internal thread.
- ***Broaching Machines -*** These machines are used for altering the size of finish of holes in metallic parts.
- ***Gear-Cutting Machines -*** These machines are used for cutting gears.
- ***Honing Machines - (already described above under separate head) :*** These machines are used for eliminating local irregularities of surface and giving good finishing.

- ***Lapping Machines* -** These machines are used for finishing cuts.
- ***Turret and Capstan Lathes* -** The operations performed on these machines by using appropriate tools are Turning, Forming, Parting off, Boring and Screw-cutting, the operations can be automatically performed in any sequence.

Machine Tools used in a Workshop:

A workshop should, in the first place, contain all the General Purpose Machines and some Special Purpose Machines according to need. A special Purpose Machine should be installed if it can be engaged for a reasonable percentage of its useful life. Otherwise General Purpose Machines should be employed, so that idle capacities of the machines may be reduced to the minimum.

The following machines are most usually found in an up-to-date machine shop manufacturing light machines and their interchangeable parts:

(1) **Lathes** – (a) Centre or Engine Lathe, (b) Capstan Lathe, and (c) Turret-Lathe.

Lathes are used mainly for Turning, Boring and Screw-cutting and can be adapted for the operations of Milling, Drilling, Slotting, Grinding, Gear and Rack cutting, Lapping, Facing, Reaming, Polishing, and Knurling, Tapping and Parting off.

The Lathe:

The following are the different kinds of Lathes : (1) Centre or Engine Lathe, (2) Capstan Lathe, (3) Turret Lathe and (4) Automatic Lathe.

Of these the Centre or Engine Lathe has been classified as a General Purpose Machine and the others as Special Purpose Machines. The Centre Lathes are extremely versatile and with proper equipment can do an endless variety of work. Capstan, Turret and Automatic Lathes have limited scope of work but can do specialized jobs with great speed and accuracy. With the modern tendency towards specialisation, Centre Lathe has been to a large extent superseded by Capstan, Turret and Automatic Lathes and Grinders.

By the term "Engine Lathe" is meant the Ordinary Centre Lathe with at least one automatic feed, either for the "traverse", or for the "surfacing".

When both the traverse and the surfacing motions are power operating the Lathe is called a "Self-acting, Sliding and Surfacing Lathe".

When a Self-acting, Sliding and Surfacing Lathe is provided with a Lead Screw for Screw-cutting, it is called a "Self-acting, Sliding, Surfacing and Screw-cutting Lathe".

The Principle of Operation of the Lathe:

In a Lathe a great deal of work is in the form of cylindrical bars. To product cylindrical surfaces the job is supported on two parts known as the Headstock and the Tailstock and is uniformly rotated by means of a mechanical device. It is clear that if a cutting tool is applied on the rotating job, cylindrical surfaces of specific diameter can be produced. The cutting tool can be operated on the entire surface of the job by moving the former parallel to the axis of rotation of the job. The rotation of the job and the motion of the cutting tool are produced by power.

Principal Parts of a Lathe:

(1) The Bed, (2) The Headstock, (3) The Tailstock, which is also called the Loose Headstock,
(4) The Carriag, (5) The Gearbox, (6) The Feed Shaft and the Lead Screw.

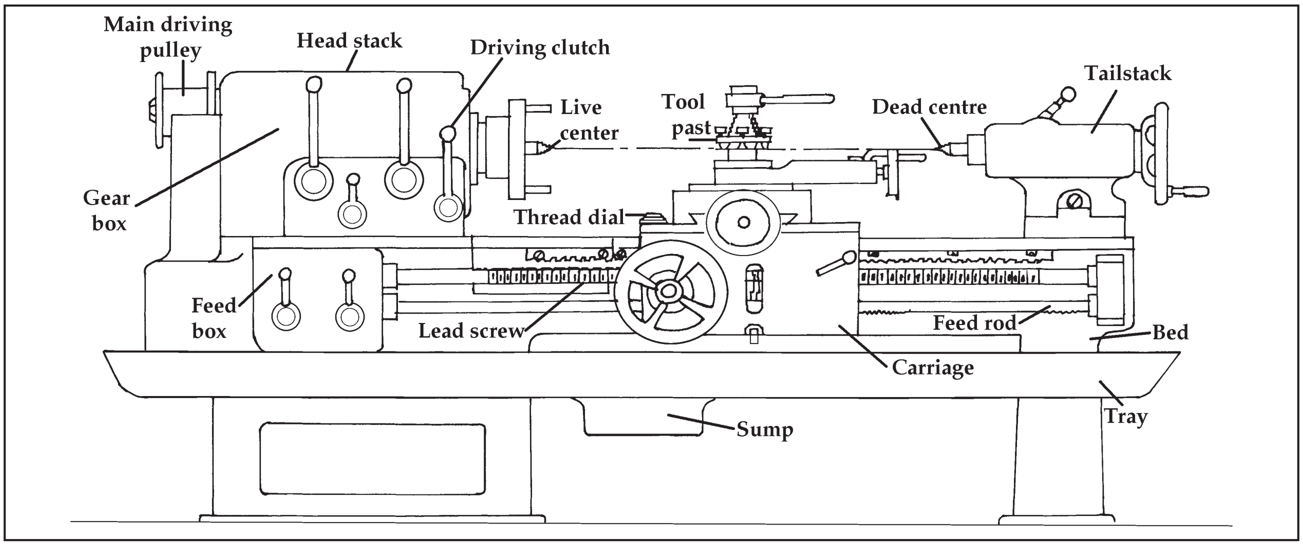


Figure of Lathe

Lathe Attachment :

Lathe Attachments are employed for increasing the adaptability of the Lathe for handling special kinds of jobs. The attachments are either devices for holding jobs or are Miscellaneous Tools suitable for different operations.

The following devices are meant to hold jobs:

(1) Special Centres and Shaft Supports.

- When the usual Headstock and Tailstock Centres are unsuitable for special kind of work, Special Centres are used.
- When a long slender shaft is turned between centres if is supportedby a device called Travelling Stay or Steady Rest attached to the Lathe Spindle.

(2) Mandrel,

(3) Chuck,

(4) Faceplate.

Miscellaneous Tools : For Drilling and Boring, Special Tools are attached to the Tailstock, so that when the job rotates, a hole is made into the job. Suitable Tools are used for other purposes.

Operations done on a Centre Lathe:

The following are the operations usually done on a Center Lathe: –

- ***Boring :*** Boring does the operation of enlarging the diameter of a hole already exist in a job. Small Boring operations are often done in the Lathe either as a single operation or preparatory to Threading, Reamering or other operations.
- ***Screw Cutting:*** this is the operation of cutting screw threads on the external surface of a cylindrical job.
- ***Turning:*** Turning means producing cylindrical surface on a job. In this operation material from the

surface of the job is removed by rotating the job against a Tool point, so as to produce a cylindrical surface. The diameter of the work may be ascertained by Callipers, Micrometers or fixed gauges.

In additional to these normal uses, a Centre Lathe can readily be adapted for the following operations: –

- ***Milling:*** Milling is the process of giving a specific shape or form to a job by cutting it by means of a revolving multiple point tool.
- ***Drilling:*** Drilling is the operation of making a hole in a job. The Drill is inserted into the Tailstock Spindle and the Tailstock is clamped to the job in the necessary position. The feed is affected by the Tailstock hand wheel.
- ***Slotting:*** This is the operation of making a long narrow aperture for something to be inserted or worked in.
- ***Grinding:*** The Grinding operation consists in applying a wheel of abrasive character rotating at high speed to a metallic surface for causing it to wear.
- ***Gear and Rack cutting:*** A Gear is a toothed wheel which, having the teeth meshed with those of another Gear, can cause one shaft to drive another. A gear having the teeth in a straight line, instead of on a circle, is called a Rack.
- ***Polishing:*** Polishing processes on job surfaces may be undertaken on a Centre Lathe.
- ***Lapping:*** Lapping is the process of polishing a work by-means of abrasive materials, to give fine finish. Lapping operation may be undertaken after grinding to give fine adjustments.
- ***Facing:*** this is an operation of producing a flat surface and removing material from the surface. The operation consists in rotating the job on an axis of rotation perpendicular to the flat surface.
- ***Reaming:*** The Reaming operation consists in (1) enlarging existing drilled holes; (2) making, a parallel hole into a tapered hole and bringing existing holes actually to size.
- ***Knurling:*** Knurling is the process of producing a series of; right-hand and left-hand fine grooves on the surface of a job to facilitate handing or to secure a better hold. Knurling operation may be accomplished by the use of either a single or double wheel Knurling Tool. The work must be mounted rigidly; either well up against Chuck Jaws or, in case of a long, slender work, a suitable Steady must be employed.
- ***Tapping:*** Tapping is the operation of forming threads on the interior surface of a job. For tapping threads a Tap should be used and the job should be very slowly rotated by engaging the Back Gear system.
- ***Parting Off:*** when work is machined from bar, the completed job can be parted off from the bar on the Centre Lathe.

Special purpose Lapping Machines are also used for this purpose.

Capstan and Turret Lathes:

The Centre Lathe is a versatile machine and can be used for many different kinds of operations. It however requires for its operation a skilled operator whose hands produce intricate and precise work. With the demand for speed and accuracy accompanied with low cost the need arose for more rapid results from less skilled personnel. As a result, Capstan and Turret Lathes were developed.

Capstan Lathe

The Capstan Lathe has the following principal parts

(1) A Bed.

(2) An all-geared Head-stock.

(3) A Saddle, in which the Cross-slide carries a revolving square Turret that can hold four Tools at once. The Turret is unlocked by means of a lever, and by turning it manually, any of the Tools in the Turret can be brought into the working position.

(4) The main Turret which replaces the Tailstock of the Centre Lathe.

Operations performed on a Capstan Lathe:

The following are the important operations performed on the Capstan Lathe:—

1. Turning, that is producing cylindrical surfaces.
2. Forming, that is turning intricate shapes by one traverse of a Tool, instead of several movements.
3. Parting-off, that is cutting away of a completed job from a bar.
4. Boring, that is enlarging the diameter of a hole already existing in a job.
5. Screw cutting, which is cutting screw threads on the external surface of a cylindrical job.

Turret Lathes

Turret Lathe is almost similar in construction to Capstan Lathe. Its principal parts are the following:—

(1) A bed.

(2) An alt-geared Headstock.

(3) A Saddle in which a revolving square Turret is carried by the Cross-Slide.

(4) The main hexagonal Turret which carries six different Tools in special holders that are bolted up to the faces.

Operations performed on a Turret Lathe:

The operations performed on a Turret Lathe and on a Capstan Lathe are the same. Generally, however, Turret Lathes are suitable for machining bigger part than Capstan Lathes.

The following are the important operations performed on a Turret Lathe:

(1) Turning,

(2) Forming,

(3) Parting-off,

(4) Boring,

(5) Screw-cutting.

Plaining Machines: are used for machining flat surfaces and cutting key-ways on large jobs. The function of this machine is same as the shaping machine but here the tool is held fixed and gives the required feed whereas the work piece is rigidly fitted on the work table with a reciprocating motion. The length of the workpiece is more than 1 metre and are normally massive.

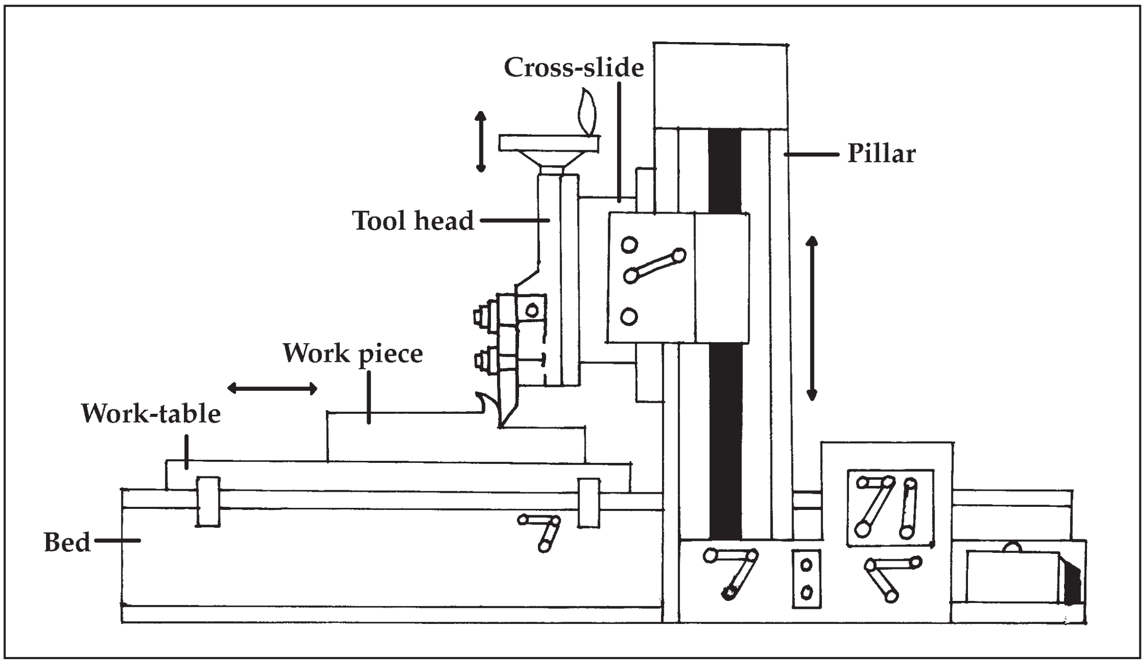


Figure of Plaining Machines

The main parts of the machine are bed, work table, cross slide pillars and tool holders as shown in figure. Tool holders, (for at least two tools) are mounted on cross beam and have provision to slide up or down along two vertical pillars fixed on two sides of the bed. After first setting, this cross beam is firmly clamped and then during operation the clapper box containing tool holders slide to give the feed.

Slotting Machines: are used for machining vertical or inclined flat surfaces, making holes with sharp corners and tapered holes and for cutting T-slots and V-ways.

For mass production, Single-purpose Machines may be used in addition to the machines mentioned above.

This is another type of a machine to produce machined fiat surface like shaper and planer. The difference with shaper or planer is that slotter makes vertical surface machining whereas the others produce horizontal machining. As such it is sometime called as "vertical shaper", since the ram holding the tool moves up and down. Base and pillar is a composite L-shaped cast structure, the pillar having a vertical machined way for the reciprocating movement of the ram. The work piece is held firm on a round table with saddle which is fitted on a horizontal bed. The round table is suitable for adjustment for the movements at right angles in horizontal plane and can also rotate about the vertical axis. The movement of the job gives the desired feed whereas movement of ram produces cutting.

The slotting machine is suitable for making keyways on inside surface of the bore of a pulley or gear or on the outside surface of a round. A typical shaping machine is shown in figure.

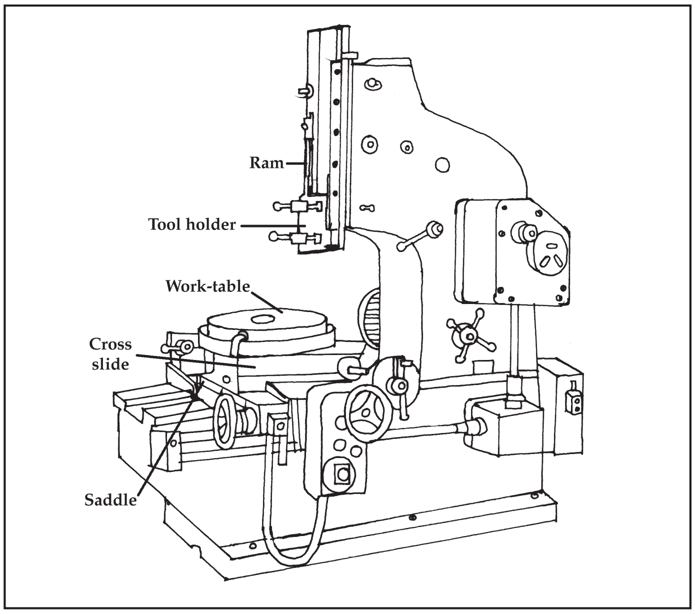


Figure of Slotting Machine

Shaping Machine:

Shaping, like Plaining, is the machining of flat metallic surfaces by single-point cutting tools. Shaping is carried out on small areas of metal not usually exceeding one foot in length. It consists of a massive body supporting the Ram which slides along ways provided on the upper surface.

There is a Saddle which supports the Work Table. The Saddle can slide up or down the face of the body and adjusts the height of the Work Table to accommodate jobs of different heights. When shaping commences, the Saddle is locked, so as to keep the job at a constant height.

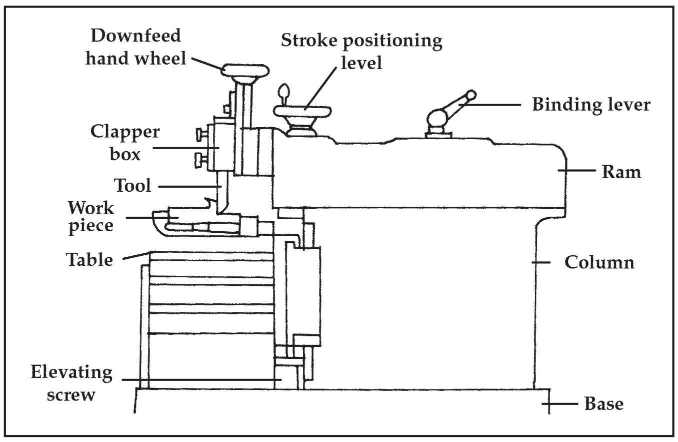


Figure of Shaping Machine

Uses of a Shaping Machine:

A Shaping Machine has the following uses:

1. ***Machining flat surfaces:*** The areas to be machined are how ever small, such as small Bed Plates of Machines.

2. ***Cutting Key-ways:*** For this purpose an aperture in the body of the machine enables shafts to be run parallel to the Ram for the provision of the Keyways.

3. ***Cutting T-slats:*** T-steps are cut in three operations. Firstly, a plain slot is cut to the required depth. Then each side is undercut by means of suitable undercutting tool to cut the side slots so that finally a slot is produced resembling the letter 'T'.

Drilling Machines:

Drilling Machines may be broadly grouped into the following four classes, such as

1. Sensitive Drilling Machines,
2. Pillar Drilling Machines,
3. Radial Drilling Machines,
4. Multiple Spindle Drilling Machines.

Sensitive Drilling Machines: Sensitive Drilling Machines are designed to take Drills up to about 8/l6 inch in diameter. They are provided with hand feed for driving the Drill forward.

The Sensitive Drills are used for making small holes only. The hand feed is provided by hand by moving the drill spindle by means of a rack and pinion arrangement. In operating these drills, pressure applied on the drill bit can be felt by the operator by his senses. These Drills are therefore called Sensitive Drills.

Pillar Drilling Machine:

A Pillar Drilling Machine is an upright Drilling Machine as distinct from a Radial Drilling Machine It consists of a Work Table on which the job to be drilled is placed.

The Work Table can be adjusted sideways and vertically to accommodate jobs of different heights.

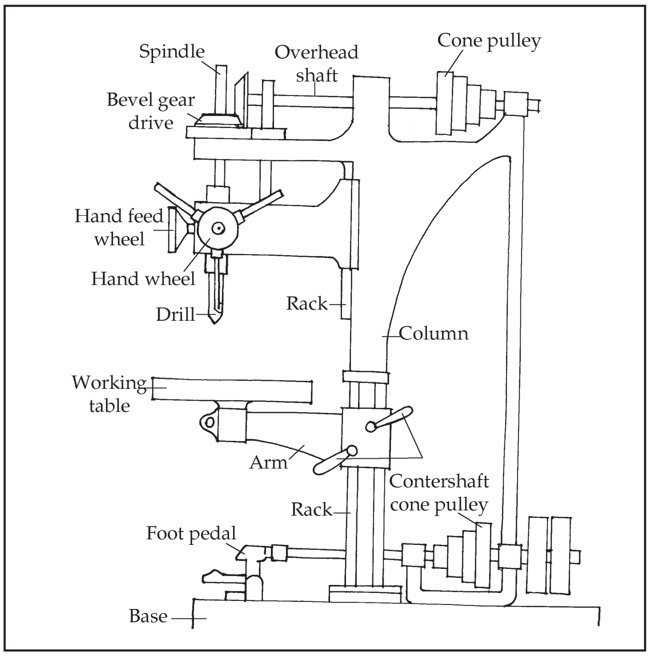


Figure of Pillar Drilling Machine

The arm carries the Spindle in a Saddle which accommodates the Spindle driving motor and the Gearboxes for providing different Spindle speeds and feeds.

Radial Drilling Machine:

Radial Drilling Machine which has a horizontal arm which is attached to a sleeve capable of moving up and down a vertical pillar and can be clamped at any position. The sleeve can freely rotate about the pillar which is fixed to the base.

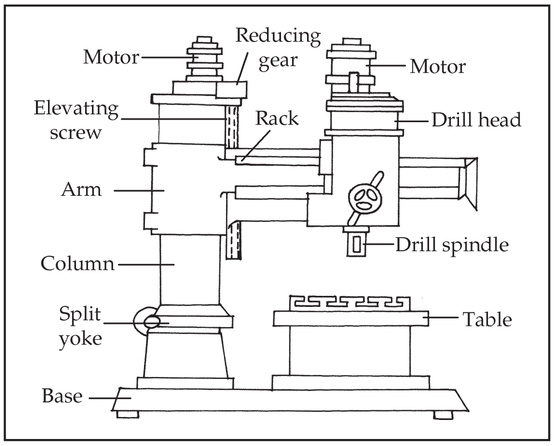


Figure of Radial Drilling Machine

The arm carries the spindle in a saddle which accommodates the spindle driving motor and the gearboxes for providing different spindle speeds and feeds.

Milling Machine:

Milling is the operation of removing metal by means of a rotating cutter against which the work is fed. The milling cutters are generally discs of cylindrical Tools-usually made of high-speed steel and have serrations or teeth about their edges.

The face of the tooth is given a definite cutting rake or angle appropriate for the material of the job to be machined.

A Milling Machine is a very important machine tool in a modern workshop. The general purpose Milling Machine may be broadly classified under (a) the horizontal milling machine and (b) the vertical milling machine.

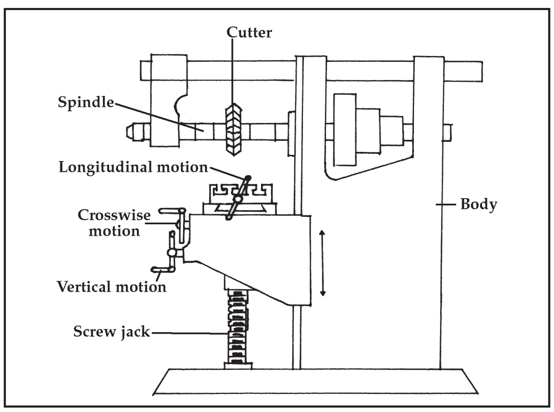


Figure of Milling Machine

In a Vertical Milling Machine the working spindle is vertical, whereas in a Horizontal Milling Machine it is horizontal.

A vertical Milling Machine is used in milling inside a recess or cavity and in performing operations which cannot be done on a Horizontal Milling Machine. There are many operations which can foe performed on the horizontal as well as on the Vertical Milling Machines.

Universal Milling Machine:

In a Universal Milling Machine the work-table can be swivelled about a vertical axis, so that its direction of travel may be at right angles or at any other angles to the spindle axis. This enables helical grooves to be cut on the outside of a cylindrical work, for instance cutting of helical teeth on gear blanks, milling of helical groove on a twist drill, etc. These operations cannot be performed on a plain milling machine in which the travel of the work-table is set permanently at right angles to the spindle axis.

Uses of a Milling Machine:

The following are the uses of a Milling Machine:—

1. Forming plain and irregular surfaces.
2. Cutting slots by using suitable Tools.
3. Cutting threads on dies, worms, screw, etc. internally or externally. Cutting threads on the Milling Machine is known as Thread Milling.
4. Gear cutting by the uses of Special Gear Cutters.

Grinding Machines are used for machining cylindrical and tapered surfaces, for grinding internal and flat surfaces and slender bars and delicate parts.

The Special Grinding:

The Grinding Process consists in machining jobs by means of abrasive wheels. In an abrasive wheel a large number of abrasive particles are held together at the periphery by means of a, bonding material. The abrasive particles act like minute cutters. When the abrasive wheel is rotated against a job, fine surface is produced by the wearing away of the materials on the job. The chips produced are usually so minute that they cannot be seen with the naked eye. The abrasive particles may be Aluminium Oxide, Silicon Carbide or Diamonds in the form of "dust".

Main Types of Grinders and their Uses:

There are four main types of Grinding Machines in common use:

1. The Cylindrical Grinders,
2. The Internal Grinding Machines,
3. The Flat Surface Grinding Machines,
4. The Centreless Grinding Machines.

The Cylindrical Grinding Machines are subdivided into. (1) Plan Grinders, (2) Universal Grinders.

The Cylindrical Grinders are used for machining parts like shafts, spindles, rollers, etc., having cylindrical surfaces and also for machining tapered parts, cams, eccentrics, soulders of shafts, etc. The Internal Grinding

Machines grind the internal surfaces of cylinders and other parts. Flat Surface Grinders are designed to machine every type of flat surface. A Centreless Grinder produces more accurately a cylindrical surface.

Of the Cylindrical Grinders the Plain Grinder is used for machine parts either cylindrical or tapered in from The Universal Grinder has a wider range of application and can be used for grinding work at any desired angle. It can be adapted to Internal Grinding and is useful in the production of part used in small machines and special tools.

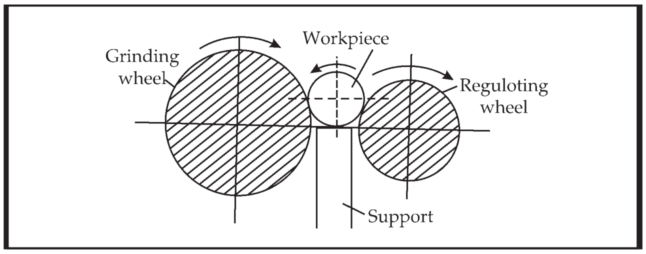


Figure of Grinding Machine

The Hobbing Machine:

The Hobbing Machine is a Single Purpose Machine Tool designed for cutting gears. Hobbing operation is the most accurate way of cutting Gears.

The cutting tool used in the Hobbing Machine is called the Hob which is in the form of a worm. A Hob is nothing more than a screw provided with "gashes" or "flutes" forming cutting edges. The cutting action is provided by the rotation of the hob, in conjunction with the gashing that provides the cutting edges.

The Hobbing Machine may be used to generate Spur Gears or Helical Gears. The Spur Gears have their teeth parallel to the axis of rotation of the Gear, while in Helical Gears the teeth are not parallel to the axis.

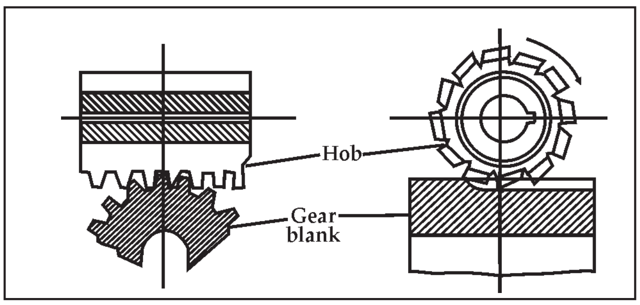


Figure of Hobbing Machine

Problem 1 :

A shaft 1,000 mm. in length is being machined on a lathe. If the spindle executes 500 r.p.m. and the feed is 0.20 mm. per revolution, how long will it take the cutter to pass down the entire length of the shaft?

Solution:

Since the feed is 0.20 mm. per revolution, the number of revolutions in passing

1,000 m.m.= $\frac{1{,}000}{0.20 \text{ m.m.}}$ =5,000. Since the spindle executes 500 r.p.m.,

the Time required = $\frac{5{,}000}{500}$ m.m. = 10 min.

Problem: 2

Find the machining cost of a M. S. bar on a lathe from the following data: R. P. M. of the Job = 500. Feed of tool per revolution of job = 0.5 mm. Depth of cut = 2 mm. Diameter of raw material = 60 mm. Diameter of finished job = 40 mm. Length of Job = 1000 mm. Machining cost = Rs. 3 per hour.

Solution :

Number of revolutions in one traverse of 1000 mm.$= \frac{1{,}000 \text{ mm.}}{0.5 \text{ mm.}} = \frac{10{,}000}{5} = 2000$

Total depth of cut = ½ (60-40) mm. = 10mm. Cross-feed = 2 mm.

The number of transverse traverse over the job from end to end = 10/2 times = 5 times.

Thus the total number of revolutions of the job = 2,000 × 5 = 10,000 R. P. M. of the job = 500

Machine time $= \frac{10{,}000}{500}$ min. = 20 min. = 1/3hr.

Cost of machining = Rs. $3 \times {}^{1}/_{3}$ = Re.1.

Problem: 3

A shaft 500 mm. in diameter and 1 metre long is to be turned at a speed of 280 r.p.m. If the feed is 0.25 mm. per revolution, calculate the time taken for one pass of the cutter.

Solution:

Length of the shaft = l metre = 1,000 mm.

Number of revolutions $= \frac{1{,}000 \text{ mm.}}{0.25 \text{ mm.}} = \frac{1{,}00{,}000}{25} = 4{,}000$

Time required for one pass of the cutter $= \frac{4{,}000}{280}$ min. $= \frac{100}{7}$ min. = 14.29 min.

Jigs and Fixtures:

A Jig is an appliance to which a work to be machined can be, fastened and which contains a device for guiding the tool, so that the tool and the work are accurately located with respect to each other. A Fixture is an appliance which holds the work when it is machined.

Uses of Jigs and Fixtures:

(1) Jigs quickly and accurately guide the tools. They render difficult operations easier, speedier and yet more accurate.

(2) Jigs are suitable is mass production for producing accurately machined interchangeable parts.

(3) Fixtures are essential almost all machine work, because the work must be firmly held when the tools work.

(4) Fixtures used in conjunction with jigs increase speed and accuracy of work.

1.4 Pumps, Motors, Transformers, Electrical Drivers

Pumps

A pump is a device used to move liquids. A pump moves liquids from lower pressure to higher pressure, and overcomes this difference in pressure by adding energy to the system (such as a water system). A gas pump is generally called a compressor, except in very low pressure-rise applications, such as in heating, ventilating, and air-conditioning, where the operative equipment consists of fans or blowers.

Pumps work by using mechanical forces to push the material, either by physically lifting, or by the force of compression.

Pumps fall into two major groups: Rotodynamic pumps and positive displacement pumps. Their names describe the method for moving a fluid. Rotodynamic pumps are based on bladed impellers which rotate within the fluid to impart a tangential acceleration to the fluid and a consequent increase in the energy of the fluid. The purpose of the pump is to convert this energy into pressure energy of the fluid to be used in the associated piping system. A positive displacement pump causes a liquid or gas to move by trapping a fixed amount of fluid or gas and then forcing (displacing) that trapped volume into the discharge pipe. Positive displacement pumps can be further classified as either rotary-type (for example the rotary vane) or lobe pumps similar to oil pumps used in car engines. Another common type is the helical twisted Roots pump. The low pulsation rate and gentle performance of this Roots-type positive displacement pump is achieved due to a combination of its two 90° helical twisted rotors, and a triangular shaped sealing line configuration, both at the point of suction and at the point of discharge. This design produces a continuous and non-verticals flow with equal volume. High capacity industrial “air compressors” have been designed to employ this principle as well as most “superchargers” used on internal combustion engines.

Reciprocating-type pumps use a piston and cylinder arrangement with suction and discharge valves integrated into the pump. Pumps in this category range from having “simplex” one cylinder; to in some cases “quad” four cylinders or more. Most reciprocating-type pumps are “duplex” (two) or “triplex” (three) cylinder. Furthermore, they are either “single acting” independent suction and discharge strokes or “double acting” suction and discharge in both directions. The pumps can be powered by air, steam or through a belt drive from an engine or motor. This type of pump was used extensively in the early days of steam propulsion (19th century) as boiler feed water pumps. Though still used today, reciprocating pumps are typically used for pumping highly viscous fluids including concrete and heavy oils.

Another modern application of positive displacement pumps are compressed air-powered double-diaphragm pumps, commonly called Sandpiper or Wilden Pumps after their major manufacturers. They are relatively inexpensive, and are used extensively for pumping water out of bunds, or pumping low volumes of reactants out of storage drums.

Centrifugal pumps are Rotodynamic pumps which convert Mechanical energy into Hydraulic energy by centripetal force on the liquid. Typically, a rotating impeller increases the velocity of the fluid. The casing, or volute, of the pump then acts to convert this increased velocity into an increase in pressure. So if the mechanical energy is converted into a pressure head by centripetal force, the pump is classified as centrifugal. Such pumps are found in virtually every industry, and in domestic service in developed countries for washing machines, dishwashers, swimming pools, and water supply.

After motors, centrifugal pumps are arguably the most common machine, and they are a significant user of energy. Given design margins, it is not unusual for a pump to be found to be over-sized, having been selected poorly for its intended duty. Running a constant speed pump throttled causes energy waste. A condition monitoring test can detect this condition and help size a smaller impeller, either new, or by machining the initial one, to achieve great energy reduction.

Pumps also wear internally, at a rate varying with the liquid pumped, materials of construction and operating regime. Again, condition monitoring can be applied to detect and quantify the extent and rate of wear and also help decide when overhaul is justified on an energy-saving basis.

Kinetic Pumps: The features are:-

- Continuous energy addition
- Conversion of added energy to increase in kinetic energy (increase in velocity)
- Conversion increased velocity to increase in pressure
- Conversion of Kinetic head to Pressure Head
- Meet all heads like Kinetic, Potential, and Pressure

Motors:

An electric motor uses electrical energy to produce mechanical energy. The reverse process that of using mechanical energy to produce electrical energy is accomplished by a generator or dynamo. Traction motors used on locomotives often perform both tasks if the locomotive is equipped with dynamic brakes. Electric motors are found in household appliances such as fans, refrigerators, washing machines, pool pumps, floor vacuums, and fan-forced ovens. Most electric motors work by electromagnetism.

The classic division of electric motors has been that of DC types and AC types.

Transformers:

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled wires. A changing current in the first circuit (the primary) creates a changing magnetic field; in turn, this magnetic field induces a changing voltage in the second circuit (the secondary). By adding a load to the secondary circuit, one can make current flow in the transformer, thus transferring energy from one circuit to the other.

A key application of transformers is to reduce the current before transmitting electrical energy over long distances through wires. Most wires have resistance and so dissipate electrical energy at a rate proportional to the square of the current through the wire. By transforming electrical power to a high-voltage, and therefore low-current form for transmission and back again afterwards, transformers enable the economic transmission of power over long distances. Consequently, transformers have shaped the electricity supply industry, permitting generation to be located remotely from points of demand. Transformers are some of the most efficient electrical 'machines', with some large units able to transfer 99.75% of their input power to their output.

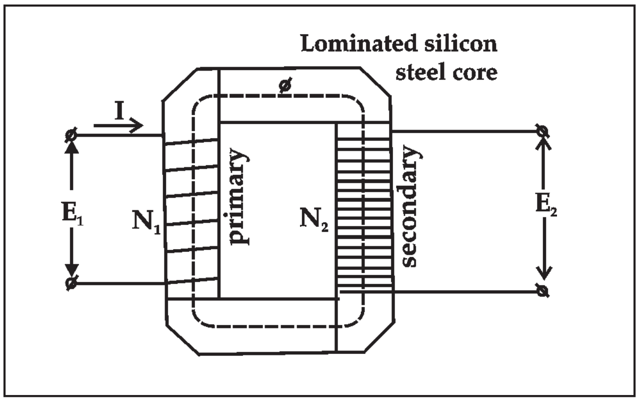


Figure of Transformer

It is defined as a stationary induction apparatus for transforming electrical energy in AC system from one circuit to another by changing voltage but without changing frequency. In its simplest form it consists of two insulated coils wound over a common magnetic core of soft iron lamination as shown in figure. The winding which receives power from the source is called "primary winding" and the winding which delivers electric power to the load is known as "secondary winding". The main purpose of transformer is to change voltage between the two windings.

The operating principle is very simple. When an AC is fed to primary winding, current flows in the winding which produces a magnetic flux within the core known as "mutual flux" which is proportional to the number of winding and the frequency of AC supply. This flux links up the secondary winding to produce an induced emf proportional to the number of turns of secondary winding. Thus if

E_1 = voltage of primary winding

N_1 = number of turns in primary coil

E_2 = voltage of secondary winding

N_2 = number of turns in secondary coil.

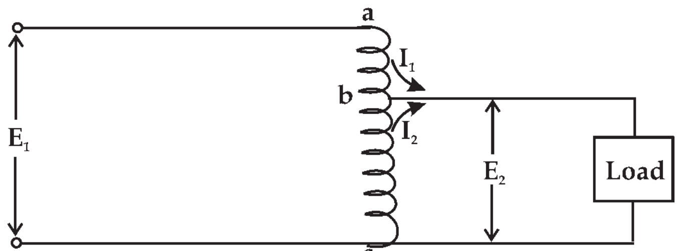
Then, $\frac{E_1}{E_2} = \frac{N_1}{N_2}$

If E_2 is greater than E_1 it is called a "step up" transformer as it increases the voltage and if E_2 is less than E_1, it is known as "step down" transformer. Since the ampere turns of primary and secondary winding remains the same and if I_1 and I_2 be the primary and secondary currents, then,

$N_1I_1 = N_2I_2$ $\quad\quad \therefore \frac{E_1}{E_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

or, $\frac{N_1}{N_2} = \frac{I_2}{I_1}$ $\quad\quad$ or, $E_1I_1 = E_2I_2$

Auto Transformer: For a very small variation in output and input voltage "double wound" transformer as explained becomes expensive and "Auto wound transformer" becomes cheaper. Auto transformer has a single winding and the secondary voltage is tapped from that winding as shown in figure.



Figure

Electrical Drivers:

A Driver is an electronic component used to control another electronic component, such as a high power transistor. A transistor is a semiconductor device, commonly used as an amplifier or an electrically controlled switch. The transistor is the fundamental building block of the circuitry in computers, cellular phones, and all other modern electronic devices.

Because of its fast response and accuracy, the transistor is used in a wide variety of digital and analog functions, including amplification, switching, regulation, signal modulation, and oscillators.

1.5 Classification of Industries Based on Production Process

Type of Industry : The type of industry and the method of the manufacturing process exercise a significant influence on plant layout.

Industries in this context may be broadly classified into four types:

(a) Synthetic,

(b) Analytical,

(c) Conditioning; and

(d) Extractive.

Extractive industries involving the separation of one element from another, as in the case of metal form the ore. Air conditioning industry involves a change in the physical properties. Metal working industries, foundries and leather tanning concerns condition their raw materials to have the end products. An oil refinery, for example, yields naphtha, gasoline, paraffin, tar and kerosene. Similarly, a sugar mill gives, besides sugar, bagasse and molasses. A synthetic industry, also called the assembling industry, involves the production of a product by the use of various elements. In other words, various elements go into the manufacture of an end-product. The chemical industry and the paper industry are synthetic industries. Light and heavy engineering and watch-making industries, in which several components are assembled to get the final products, also fall under synthetic industries.

Each of the above types of industries may be further classified into two types, namely:

(a) Intermittent industries; and

(b) Continuous industries.

This classification is based on the method of manufacture. The former type of industries manufactures different components on different machines and assembles them to get the end products. Continuous industries uninterruptedly produce one or two products of a standardise nature. It is needless to emphasise that the layout designer should keep in mind the type of industry and the method of the manufacturing process while Plaining a layout.

Intermittent production system situations are those where the facilities must be flexible enough to handle a wide variety of products and sizes or where the basic nature of activity imposes change of important characteristics the input (change in product design). Under this system no single sequence of operations is appropriate and therefore standardized materials or machines cannot be used. Under this type of manufacturing, production is done in lots rather that on a continuous flow basis. It is done more often on the basis of customer orders.

The chief characteristics of intermittent industries are that components are made for inventory but they are combined differently for different customers. The finished product is heterogeneous but within a range of standardized options assembled, by the producers. Since production is partly for stock and partly for customer demand, there are problems to be met in scheduling, forecasting, control and coordination. Examples of such industries are automobile industry, electrical goods manufacturing plants, printing presses etc.

Intermittent system of production may further be divided into two types, namely (a) job and (b) batch production.

(a) Job Production - In this system, goods are produced according to the orders of the customers. Continuous demand of such items is hot assured and therefore production is done only when the orders for the manufacturing of items are produced from the customers.

(b) Batch Production - Under this system, the manufacturing is done in batches or groups or lots either on the basis of customer’s order or with a hope of a continuous demand of the product. Under this system, medium scale production is warranted.

In batch production, machines and equipment are made available for the next batch as soon as the production of first batch is completed.

Continuous production situations are those where facilities are standardized as to routing and flow since the raw material or inputs are standardized. Therefore, a standard set of processes and sequences of processes are adopted. Such processes are adopted by concerns which produce goods or services continuously by putting them through a series of successive connected operations in anticipation of customer demand rather than in response to customer orders. Examples of industries using such technology are petroleum, chemicals, steel and sugar industry.

We can again classify the continuous industries into

(1) Mass production system and (2) Process production system.

(a) Mass Production - This system of production is used by concerns where manufacturing is carried on continuously in anticipation of demand, though demand of the product may not be uniform throughout the year. Standardization is the keynote of mass production. Standardized raw materials and machines are used to produce standardized products through standardized process of production.

(b) Process Production - This system is an extended form of mass production where production is carried on continuously through, a uniform predetermined sequence of operations. Generally under this system finished product of one process is used in the next process as a raw material till the last process. Process production calls for the setting up of automatic machines and equipment as far as possible. Large industries like petroleum refining, heavy chemical industries generally use this system of production.

1.6 Technological Aspects of Different Production Process Like Power, Pollution control & Recovery Process

Power: This is an important factor in the industry and can provide the competitive edge. From the days of a hefty power consumption of 140 units per tonne of cement, the consumption is about 90-100 units. Availability of power is another problem and almost all companies have gone in for massive power generating sets to improve their working.

Recovery Process - Waste Management:

There are various ways in which one could categorise waste. However, the generally accepted classification is given below:

(i) Classification on the basis of Resources, i.e., how much of a particular resource has been wasted.

(ii) Classification on the basis of property i.e. whether the materials that have been wasted are hazardous to life and environment or whether they fall in the category of non-hazardous.

(iii) Classification on the basis of the recoverability of resources.

(iv) Classification on the basis of origin of waste, i.e., whether it is commercial waste or industrial waste, residential waste or office waste and construction waste or agricultural waste.

The chief objectives of waste management are as follows:

- Minimisation of overall waste in any operating system under scrutiny.
- Maximisation of previous resources, so that these are not frittered away and the opportunity cost is bare minimum.
- To cut down on all the unnecessary activities which do not add value to the system.
- To increase the profitability of the operation followed by different organisations.
- To inculcate a sense of cost-effectiveness which could trigger off the prudent practices of Total Cost Management (TCM).
- To follow the ethics and the principles of Total Quality Management (TQM).
- To aspire for international recognition, vital to face the competition prevailing in the current global as well as the domestic market.

Attributes of effective waste collection system:

An efficient waste collection system serves the organisation in more ways than one. It may be extremely costly to install and operate, but once handled properly, provides substantial savings to the organsiation by providing the operating costs and other overheads. The structure of an effective waste collection system depends on the following key factors.

1. Identify the waste.
2. Waste-separation at source.
3. Decide about the quantity to be stored in a particular container.
4. Decide about the physical dimensions other important attributes of the container.
5. Collect the waste in these containers.
6. Make projections of the rate of waste generation.
7. Depending on the above, ensure that the waste collection is timely and proper without any delays or bottlenecks.
8. Induce some kind of benefits—whether monetary inducements or otherwise to the employees collecting the waste at source.
9. Motivational and other techniques can be effectively used to achieve the above defined result.
10. Make provisions to transport the waste so collected to the salvage industry or the localised unit, as the case may be.
11. Collect the available organic wastes.
12. Ensure that the inorganic wastes are not left behind.
13. Clearly differentiate between the different types of waste.
14. Handling each container on the basis of the waste-type stored in these.
15. Keep an emergency or contingency plan ready.

Recycling of wastes

Often the waste generated across the industries can be recycled and used again and again. However, it is not as simple as it appears to be. Certain appropriate recycling projects have to be created to achieve such results.

Features of waste disposal system:

The salient features of an effective waste proposal system are as follows:

1. Easy to install and operate.
2. Economical from the cash outflow point of view.
3. Convenient and not highly complex.
4. Within the budgetary constraints.
5. Approved by the legislation and other statutory authorities in force.
6. Flexibility and not rigidity in operations.
7. Economies of scale.
8. Does not require highly skilled labour force for its operation.
9. Adaptability in the context of the needs and objectives of the organsiation.

Pollution Control:

Pollution can be of four types, on the basis of the forms:

(i) Solid – type , (ii) Liquid – type, (iii) Gaseous pollutants, (iv) Hybrid-type, having features and characteristics of one or more of the above three.

Definition and meaning of noise-pollution - Noise may be defined as an unwelcome, unpleasant, unwanted and unavoidable sound. For example it can be classified as under:

Unpleasant Noise - Sources of such noise are, predominantly:

(i) Industrial outlets.

(ii) Increased automation.

(iii) Lack of work culture.

(iv) Lack of awareness.

(v) No concern for the environmental and other allied issues.

Unavoidable Noise: Unavoidable noise is a part and parcel of our daily life. We simply cannot escape from it. It is one of the prices one has to pay foil modern living. These are from:

(i) Regular sources.

(ii) Work-places/stations.

(iii) Use of machines.

(iv) Limited and restricted choices.

Other types could be vibration. People exposed to it for longer periods are likely to suffer from fatigue and exhaustion – which may prove to be quite costly in the long run.

Objectives of pollution control

Although the main aims of pollution control are simple enough, i.e. "to make the world a better place to live in", the sub-objectives and the strategies adopted for this purpose are given below:

1. Environmental preservance.
2. Ecological balance.
3. Dignity of life for all and sundry.
4. Protection from physical diseases.
5. Protection and prevention from mental impairment.
6. To maintain the right balance between the nature's bountiful resources and to protect them.
7. To increase the life expectancy.
8. To enjoy a stress-free high quality existence.
9. To increase the employees productivity.
10. To boost up the organisational growth at the micro level.

11. To felicitate nations to be more competitive at a macro level.
12. To integrate and synthesise the world as one at the global level.

Control of pollution : Pollution cannot effectively be controlled by the use of a single technique. Since the causes and the effects of different types of pollution are diverse and distinct from each other, there cannot be any thumb- rule or golden rule which could be applied in the present context. However, in general, a prudent use of the techniques given below, in conjunction with other appropriate measures, is bound to bring in the desired results. These are:

1. Controlling at source.
2. Controlling during processes, operations and other activities.
3. Control by suitable enclosures.
4. Control by protection.
5. Control by preventions.
6. Control by absorption.
7. Adhering to regulations laid down by the following authorities:
   (a) Respective state governments.
   (b) Central Government.
   (c) Guidelines issued by the global bodies representing individual pollution control measures.
   (d) Ensuring compliance with any other law for the time being in force.

1.7 PLANT LAYOUT

Plant Layout, also known as layout of facility refers to the configuration of departments, work-centres and equipment and machinery with focus on the flow of materials or work through the production system.

Plant layout or facility layout means planning for location of all machines, equipments, utilities, work stations, customer service areas, material storage areas, tool servicing areas, tool cribs, aisles, rest rooms, lunch rooms, coffee/tea bays, offices, and computer rooms and also planning for the patterns of flow of materials and people around, into and within the buildings. Layout planning involves decisions about the physical arrangement of economic activity centres within a facility. An economic activity centre can be anything that consumes space, a person or group of people, a machine, a work station, a department, an aisle, a store room and so on. The goal or layout planning is to allow workers and equipments to operate more effectively.

The questions to be addressed in layout planning are:

- How much space and capacity does each centre need?
- How should each center's space be configured?
- What centres should the layout include?
- Where should each centre be located?

The location of a centre has two dimensions:

- Absolute location or the particular space that the centre occupies within the facility.
- Relative location i.e., the placement of a centre relative to other centers.

The importance of layout decisions:

The need for layout planning arises both in the process of designing new plants and the redesigning existing plants or facilities.

Most common reasons for design of new layouts are:

(i) Layout is one of the key decisions that determine the long-run efficiency in operations.

(ii) Layout has many strategic implications because it establishes an organisation's competitive priorities in regard to capacity, processes, flexibility and cost as well as quality of work life, customer contact and image (in case of service organisations).

(iii) An effective layout can help an organisation to achieve a strategic advantage that supports differentiation, low cost, fast response or flexibility.

(iv) A well designed layout provides an economic layout that will meet the firm's competitive requirements.

Need for redesign of layout arises because of the following reasons:

- Accidents, health hazards and low safety,
- Changes in environmental or legal requirements,
- Changes in processes, methods or equipments,
- Changes in product design/service design,
- Changes in volume of output or product-mix changes,
- Inefficient operations (high cost, bottleneck operations),
- Introduction of new products/services,
- Low employee morale.

Good Plant layout- Objectives:

- Efficient utilisation of labour reduced idle time of labour and equipments,
- Higher flexibility (to change the layout easily),
- Higher utilisation of space, equipment and people (employees),
- Improved employee morale and safe working conditions,
- Improved flow of materials, information and people (employees),
- Improved production capacity,
- Reduced congestion or reduced bottleneck centers,
- Reduced health hazards and accidents,
- Reduced material handling costs,

- To allow ease of maintenance,
- To facilitate better coordination and face-to-face communication where needed,
- To improve productivity,
- To provide ease of supervision,
- To provide product flexibility and volume flexibility,
- To utilise available space efficiently and effectively.

Choices of Layout:

Layout choices can help greatly in communicating an organisation's product plans and competitive priorities. Layout has many practical and strategic implications. Altering a layout can affect an organisation and how well it meets its competitive priorities by:

- Facilitating the flow of materials and information,
- Improving communication,
- Improving employee morale,
- Increasing customer convenience and sales (in service organisations such as retail stores),
- Increasing the efficient utilisation of labour and equipment,
- Reducing hazards to employees.

The type of operations carried out in a firm determines the layout requirements.

Some of the fundamental layout choices available to managers are:

- Whether to plan the layout for the current or future needs?
- Whether to select a single-story or multistory building design?
- What type of layout to choose?
- What performance criteria to emphasise?

Factors influencing layout choices:

Primarily the layout of a plant is influenced by the relationship among materials, machinery and men. Other factors influencing layout are type of product, type of workers, the type of industry, management policies etc.

Some of these factors are discussed in detailed below:

- ***Location:*** The size and type of the site selected for the plant, influences the type of buildings (single story or multi story) which in turn influences the layout design. Also, the location of the plant determines the mode of transportation from and into the plant (such as by goods trains, truck, or ships) and the layout should provide facilities for mode of transport used. Also, the layout should provide for storage of fuel, raw materials, future expansion needs, power generation requirements etc.
- ***Machinery and Equipments:*** The type of product, the volume of production, type of processes and management policy on technology, determines the type of machines and equipments to be installed which in turn influence the plant layout.

- ***Managerial Policies:*** regarding volume of production, provision for future expansion, extent of automation, make-or-buy decisions, speed of delivery of goods to customers, purchasing and inventory policies and personnel policies influence the plant layout design.
- ***Materials:*** Plant layout includes provision for storage and handling of raw materials, supplies and components used in production. The type of storage areas, racks, handling equipments such as cranes, trolleys, conveyors or pipelines etc., used - all depend on the type of materials used - such as solid, liquid, light, heavy, bulky, big, small etc.
- ***Product:*** The type of product i.e., whether the product is light or heavy, big or small, liquid or solid etc., it influences the type of layout. For example, Ship building, Aircraft assembly, Locomotive assembly etc., requires a layout type different from that needed to produce refrigerators, cars, scooters, television sets, soaps, detergents, soft drinks etc. The manufacturing process equipments and machines used and the processing steps largely depend on the nature of the product and hence the layout design depends, very much on the product.

Type of Industry:

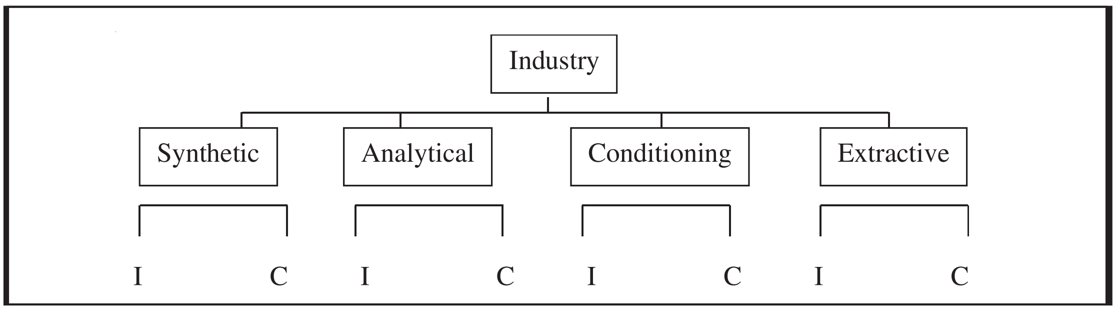


Figure : Type of Industry Process

I is intermittent type of industry
C is continuous type of industry
Whether the industry is classified under (a) Synthetic, (b) Analytical, (c) Conditioning and (d) Extraction industries and again whether the industry has intermittent production or continuous production has a relevance to the type of layout employed.

- ***Workers :*** The gender of employees (men or women), the position of employees while working (i.e., standing or sitting), employee facilities needed such as locker rooms, rest rooms, toilets, canteens, coffee/tea bays etc., are to be considered while designing the plant layouts.

Plant Layout- Principles:

The layout selected in conformity with layout principles should be an ideal one. These principles are:-

- ***Principle of Minimum Travel:*** Men and materials should travel the shortest distance between operations so as to avoid waste of labour and time and minimise the cost of materials handling.
- ***Principle of Sequence:*** Machinery and operations should be arranged in a sequential order. This principle is best achieved in product layout, and efforts should be made to have it adopted in the process layout.
- ***Principle of Usage:*** Every unit of available space should be effectively utilised. This principle should receive top consideration in towns and cities where, land is costly.

- ***Principle of Compactness:*** There should be a harmonious fusion of all the relevant factors so that the final layout looks well integrated and compact.
- ***Principle of Safety and Satisfaction:*** The layout should contain built in provisions for safety for the workmen. It should also be planned on the basis of the comfort and convenience of the workmen so that they feel satisfied.
- ***Principle of Flexibility:*** The layout should permit revisions with the least difficulty and at minimum cost.
- ***Principle of Minimum Investment:*** The layout should result in savings in fixed capital investment, not by avoiding installation of the necessary facilities but by an intensive, use of available facilities.

Types of Layout:

A layout essentially refers to the arranging and grouping of machines which are meant to produce goods. Grouping is done on different lines. The choice of a particular line depends on several factors. The methods of grouping or the types of layout are:

(i) Process layout or functional layout or job shop layout; (ii) Product layout or line processing layout or flow-line layout; (iii) Fixed position layout or static layout; (iv) Cellular manufacturing (CM) layout or Group Technology layout and (v) Combination layout or Hybrid layout.

Process Layout:

Also called the functional layout, layout for job lot manufacture or batch production layout, the process layout involves a grouping together of similar machines in one department. For example, machines performing drilling operations are installed in the drilling department; machines performing turning operations are grouped in the turning department; and so on. In this way, there would be an electro-plating department, a painting department, a machining departments and the like, where similar machines or equipments are installed in the plants which follow the process layout. The process arrangement is signified by the grouping together of like machines based upon their operational characteristics. For example, centre lathes will be arranged in one department, turret lathes in a second department, and milling machines in a third departments.

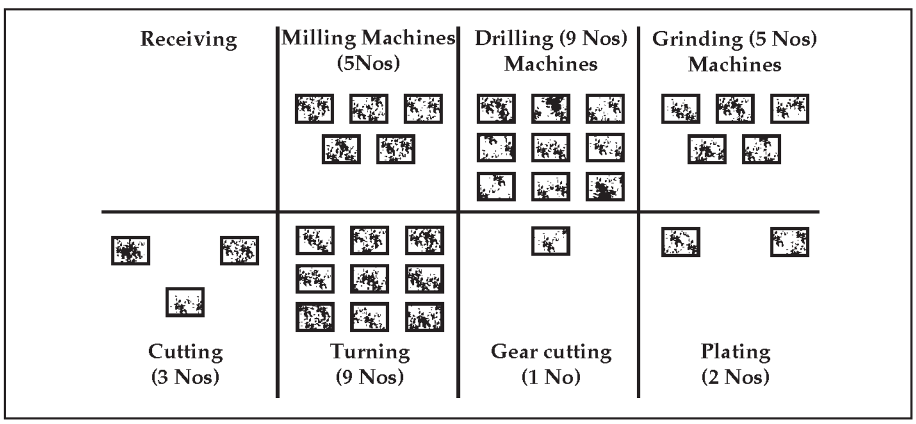


Figure of Prosses Layout

A quantity of raw material is issued to a machine which performs the first operation. This machine may be situated anywhere in the factory. For the next operation, a different machine may be required, which may be situated in another part of the factory. The material should be transported to the other machine for the operation. Thus, material would move long distances and along crisscrossing paths. At one stage, the material may be taken to a separate building, say, for heat treatment, and then brought back for grinding. If machines in one department are engaged, the partly finished product awaiting operations may be taken to the store and later reissued for production. Partly finished goods would be waiting for processing in every department, like commuters waiting for buses in a city.

Machines in each department attend to any product that is taken to them. These machines are, therefore, called general purpose machines. Work has to be allotted to each department in such a way that no machine in any department is idle. In a batch production layout, machines are chosen to do as many different jobs as possible, i.e., the emphasis is on general purpose machines. The work which needs to be done is allocated to the machines according to loading schedules, with the objective of ensuring that each machine is fully loaded. The process layout carries out the functional idea of Taylor and from the historical point of view, process layout precedes product layout. This type of layout is best suited for intermittent type of production.

While grouping machines according to the process type, certain principles must be kept in mind. These are:

- Convenience for inspection.
- Convenience for supervision. Process layout may be advantageously used in light and heavy engineering industries, made-to-order furniture industries and the like.
- The distance between departments needs to be as short as possible with a view to avoiding long-distance movement of materials.
- Though similar machines are grouped in one department, the departments themselves should be located in accordance with the principle of sequence of operations. For example, in a steel plant, the operations are smelting, casting; rolling etc. These different departments may be arranged in that order to avoid crossovers and backtracking of materials.

Product Layout:

Also called the straight-line layout or layout for serialised manufacture, the product layout involves the arrangement of machines in one line depending upon the sequence of operations. Material is fed into the first machine and finished products come out of the last machine. In between, partly finished goods move from machine to machine, the output of one machine becoming the input for the next. In a sugar mill, sugar cane, fed at one end of the mill comes out as sugar at the other end. Similarly, in paper mill, bamboos are fed into the machine at one end and paper comes out at the other end.

In product layout, if there are more than one, line of production, there are as many, lines of machines. The emphasis here, therefore, is on special purpose machines in contrast to general purpose machines, which are installed in the process layout. Consequently, the investment on machines in a straight line layout is higher than the investment on machines in a functional layout.

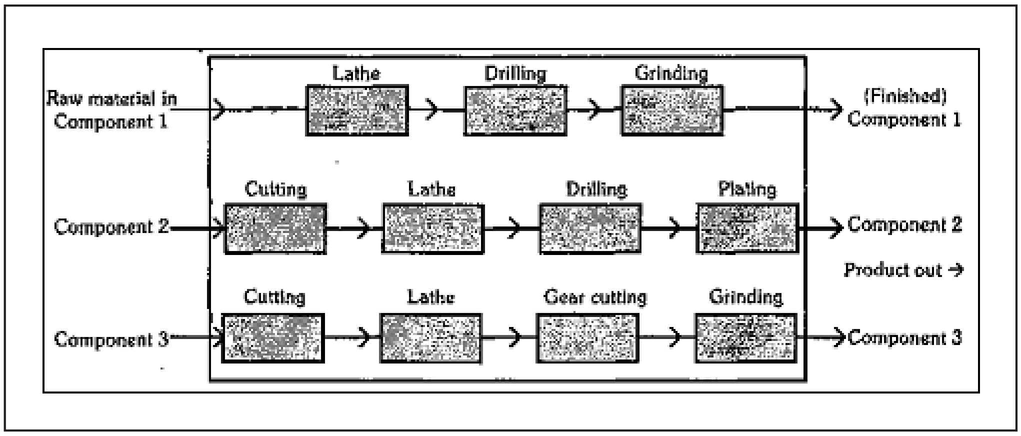


Figure of Product Layout

The grouping of machines should be done, on product line, keeping in mind the following principles:

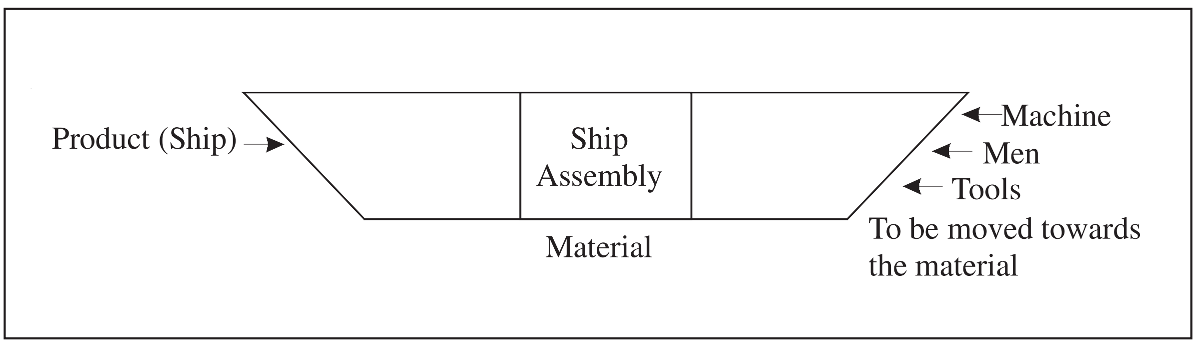
- All the machine tools or other types of equipment must be placed at the point demanded by the sequence of operations.
- All the operations, including assembly, testing and packing should be, included in the line.
- Materials may be fed where they are required for assembly but not necessarily all at one point; and
- There should be no points where one line crosses another line;

The product layout may be advantageously followed in plants manufacturing standardised products on a mass scale such as chemical, paper, sugar, rubber, refineries and cement industries.

Layout in the form of Fixed Position:

As the term itself implies, the fixed position layout involves the movement of men and machines to the product which remains stationary. In this type of layout, the material or major component remains in a fixed location, and tools, machinery and men as well as other pieces of material are brought to this location. The movement of men and machines to the product is advisable because the cost of moving them would be less than the cost of moving the product which is very bulky.

Also called static layout, this type is followed in the manufacture, if bulky and heavy products, such as locomotives, ships, boilers, air crafts and generators.



Mixed Layout or Combined Layout:

The application of the principles of product layout, process layout or fixed location layout in their strict meanings is difficult to come across. A combination of the product and process layouts, with an emphasis on either, is noticed in most industrial establishments. Plants are never laid out in either pure form. It is possible to have both types of layout in an efficiently combined form if the products manufactured are somewhat similar and not complex.

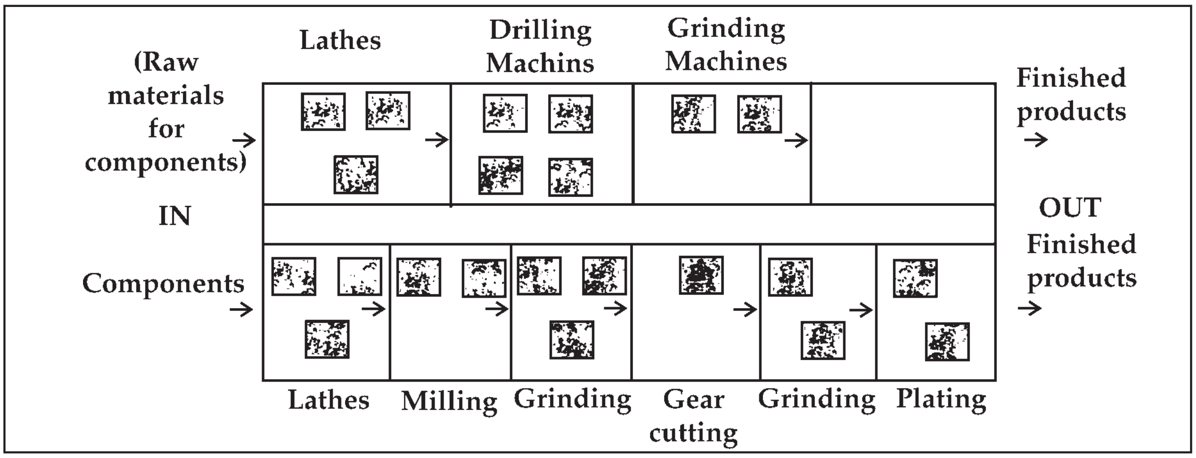


Fig. Component flow in combined layout

Layout of Service Facility:

The fundamental difference between service facility and manufacturing facility layouts is that many service facilities exist to bring together customers and services. Service facility layouts should provide for easy entrance to these facilities from freeways and busy thoroughfares. Large, well organized and amply lighted parking areas and well designed walkways to and from parking areas are some of the requirements of service facility layouts.

Because of different degree of customer contact, two types of service facility layouts emerge, viz., those that are almost totally designed around the customer receiving and servicing function (such as banks) and those that are designed around the technologies, processing of physical materials and production efficiency (such as hospitals).

Other facilities with reference to Plant Layout:

A plant layout involves, besides the grouping of machinery, an arrangement for other facilities as well. Such facilities include receiving and shipping points, inspection facilities, employee facilities and storage. Not all the facilities are required in every plant. The requirements depend on the nature of the product which is manufactured in a particular plant.

Importance of layout:

The importance of a layout can be described as under:

- ***Avoidance of Bottlenecks:*** Bottlenecks refer to any, place in a production process where materials tend to pile up or produced at rates of speed less rapid than the previous or subsequent operations. Bottlenecks are caused by inadequate machine capacity, inadequate storage space or low speed on the part of the operators. The results of bottlenecks are delays in production schedules, congestion, accidents and wastage of floor area. All these may be overcome with an efficient layout.

- ***Avoidance of Unnecessary and Costly Changes:*** A planned layout avoids frequent changes which are difficult and costly. The incorporation of flexibility elements in the layout would help in the avoidance of revisions.
- ***Better Production Control:*** Production control is concerned with the production of a product of the right type at the right time and at reasonable cost. A good plant layout is a requisite of good production control and provides the plant control officers with a systematic basis upon which to build organisation and procedures.
- ***Better Supervision:*** A good plant layout ensures better supervision in two ways: (a) Determining the number of workers to be handled by a supervisor and (b) Enabling the supervisor to get a full view of the entire plant at one glance. A good plant layout is, therefore, the first step in good supervision.
- ***Economies in Handling:*** Nearly 30 per cent to 40 per cent of the manufacturing costs are accounted for by materials handling. Every effort should, therefore, be made to cut down en this cost. Long distance movements should be avoided and specific handling operations must he eliminated.
- ***Effective Use of Available Area:*** Every unit of the plant area is valuable, especially in urban areas. Efforts should be therefore, be made to make use of the available area by planning the layout properly.
- ***Improved Employee Morale:*** Employee morale is achieved when workers are cheerful and confident. This state of mental condition is vital to the success of any organisation. Morale depends on better working conditions; better employee facilities; reduced number of accidents; and increased earnings.
- ***Improved Quality Control:*** Timely execution of orders will be meaningful when the quality of the output is not below expectations. To ensure quality, inspection should be conducted at different stages of manufacture. An ideal layout provides for inspection to ensure better quality control.
- **I*mproved Utilisation of Labour:*** A good plant layout is one of the factors in effective utilisation of labour. It makes possible individual operations, the process and flow of materials handling in such a way that the time of each worker is effectively spent on productive operations.
- ***Minimisation of Production Delays:*** Repeat order and new customers will be the result of prompt execution of orders. Every management should try to keep to the delivery schedules.
- ***Minimum Equipment Investment:*** Investment on equipment can be minimised by planned machine balance and location, minimum handling distances, by the installation of general purpose machines and by planned machine loading. A good plant layout provides all these advantages.

Good Layout - Characteristics:

- Effective coordination and integration among men, materials and machinery to maximise utilisation and output.
- Facilitates supervision and control.
- Flexibility for change of layout, expansion, changes in product design and process.
- Good working conditions - lighting, ventilation, temperature, humidity etc., are as per requirements.
- Maximum utilisation of available space.
- Proper location of storage areas.

- Provision of safety and reduction of accidents.
- Smooth flow of production (i.e., raw materials and workers).
- Smooth movement of men, materials and machinery from place to place.

Layout planning and design:

The layout process starts with an analysis of the product to be manufactured and the expected volume of its production. An analysis of the product includes a study of the parts to be manufactured and/or bought and the stages at which they should be assembled to obtain the end product (i.e., finished product). The volume of production is estimated based on the demand and the installed capacity.

For a given product, at a desired volume of production the most appropriate process is determined. The process which is selected, in turn determines the type of equipments or machinery that would be required to manufacture the product at 'given volume. The type of machines or equipments could be of general purpose or special purpose depending on the number of products produced (i.e., a standard product or a product-line or product-mix) and the volume of production (i.e., batch production, mass production or continuous production). The type of production determines the type of layout which is most suitable to the type of production and the process selected. The capacity planning determines the number of machines of each type required to produce a given volume of the product or products. The modern trend is to go for advanced manufacturing technology and automation with a trend to use capital intensive production facilities rather than labour-intensive. This results in increased production, better quality products, higher productivity, shorter manufacturing cycles and reduced interruptions in production due to labour problems etc.

Once the process and equipments needed to carryout the process are determined, the number of direct operators and indirect labour for activities such as planning, material handling, quality control , maintenance, industrial engineering, tool room, tool servicing etc., are determined. The facility planning and design must take into consideration the space requirements for all the direct and indirect facilities including, equipments, machinery, labour, inspection areas, storage areas, utilities and services and so on. Once all these requirements are planned, the Civil Engineers, Architects, Plant Engineering personnel all work together to prepare the Blue prints for the layout design of manufacturing shops and the entire plant.

Problems & Solutions

Problem: 1

A company is planning to undertake the production of medical testing equipments has to decide on the location of the plant. Three locations are being considered, namely, A, B and C. The fixed costs of three locations are estimated to be Rs. 300 Lakhs, 500 Lakhs and 250 Lakhs respectively. The variable costs are Rs. 3000, Rs. 2000 and Rs. 3500 per unit respectively. The average sales price of the equipment is Rs. 7000 per unit. Find

(i) The range of annual production/sales volume for which each location is most suitable.

(ii) Select the best location, if the sales volume is of 18,000 units.

Solution:

Determination of total costs of three locations.

Total cost = Fixed cost + [volume or quantity produced] × [variable cost]

= F + x.v where 'x' is the quantity to be produced.

a. Total cost at A = 3,00,00,000 + 3,000x .... (1)

b. Total cost at B = 5,00,00,000 + 2,000x .... (2)

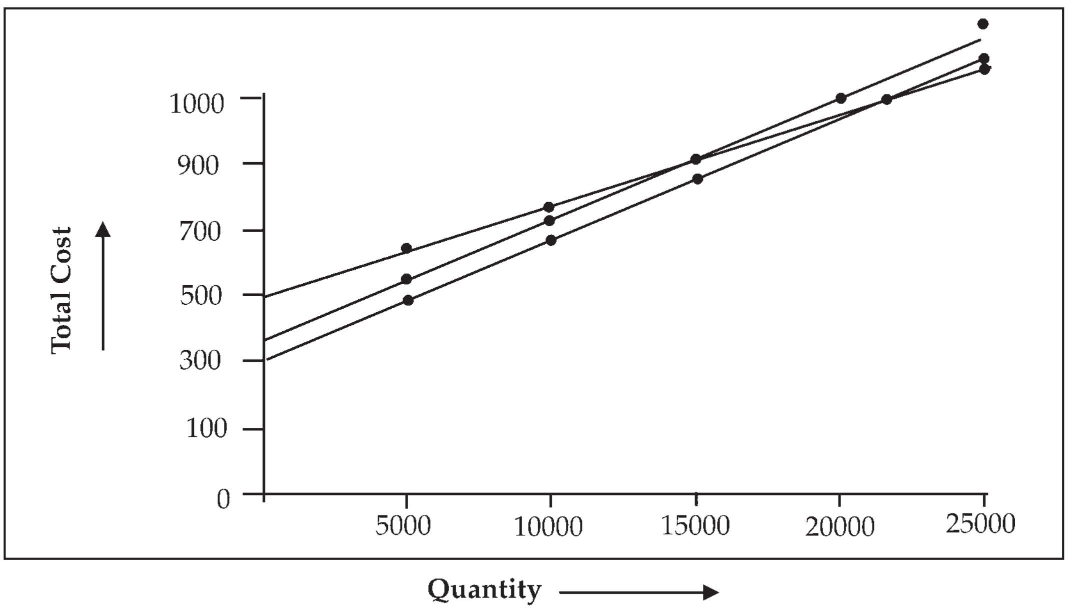
c. Total cost at C = 2,00,00,000 + 3,500x .... (3)

For the various volumes of production, i.e., 5,000, 10,000, 15,000, 20,000 and 25,000 units, the total costs are computed at the three locations and they are plotted as shown in figure.

Table: Total costs at different volumes for three locations

(Rs. in Lakhs)

Volume (Nos)	5,000	10,000	15,000	20,000	25,000
A	450	600	750	900	1,050
B	600	700	800	900	1,000
C	425	600	775	950	1,125



Decision Rules

For quantities upto 20,000 units, C is the most economical location. For quantities above 22,000, A is the preferred location.

Problem: 2

The present layout is shown in the figure. The manager of the department is intending to interchange the departments C and F in the present layout. The handling frequencies between the departments is given. All the departments are of the same size and configuration. The material handling cost per unit length travel between departments is same. What will be the effect of interchange of departments C and F in the layout?

A	C	E
B	D	F

From / To	A	B	C	D	E	F
A	–	0	90	160	50	0
B	–	–	70	0	100	130
C	–	–	_	20	0	0
D	–	–	–	_	180	10
E		–	–	–	–	40
F	–	–	–	–	–	–

From / To	A	B	C	D	E	F
A		1	1	2	2	3
B			2	1	3	2
C				1	1	2
D					2	1
E						1
F						–

(ii) Computation of total cost matrix (combining the inter departmental material handling frequencies and distance matrix.

From / To	A	B	C	D	E	F	Total
A		0	90	320	100	0	510
B			140	0	300	260	700
C				20	1	0	20
D					360	10	370
E						40	40
F							–
Total							1,640

If the departments are interchanged, the layout will be represented as shown below.

A	C	E
B	D	F

The distance matrix and the cost matrix are represented as shown.

From / To	A	B	C	D	E	F
A		1	3	2	2	1
B			2	1	3	2
C				1	1	2
D					2	1
E						1
F						

Total cost matrix for the modified layout.

From / To	A	B	C	D	E	F	Total
A	–	0	270	320	100	0	690
B			140	0	300	260	700
C				20	1	0	20
D					360	10	370
E						40	40
F							–
Total							1,820

The interchange of departments C and F increases the total material handling cost. Thus, it is not a desirable modification.

Problem: 3

A defence contractor is evaluating its machine shops current process layout. The figure below shows the current layout and the table shows the trip matrix for the facility. Health and safety regulations require departments E and F to remain at their current positions.

E	B	F
A	C	D

Current Layout

From / To	A	B	C	D	E	F
A		8	3		9	5
B		-		3		
C			-		8	9
D				-		3
E					-	3
F						-

Can layout be improved? Also evaluate using load distance (ld) score.

Solution:

Keep the departments E and F at the current locations. Because C must be as close as possible to both E and F, put C between them. Place A directly south of E, and B next to A. All of the heavy traffic concerns have been accommodated. Department D is located in the remaining place. The proposed layout is shown in figure below. The load distance (ld) scores for the existing and proposed layout are shown below. As Id score for proposed layout is less, the proposed layout indicates improvement over existing.

E	C	F
A	B	D

Proposed Layout

Dept. Pair	No. of Trips (1)	Existing plan		Proposed plan	
		Distance (2)	Load × Distance (1 × 2)	Distance (3)	Load × Distance (1 ×3)
A–B	8	2	16	1	8
A–C	3	1	3	2	6
A–E	9	1	9	1	9
A–F	5	3	15	3	15
B–D	3	2	6	1	3
C– E	8	2	16	1	8
C–F	9	2	18	1	9
D–F	3	1	3	1	3
E–F	3	2	6	2	6
Total			92		67

Problem: 4

Location A would result in annual fixed cost of Rs. 3,00,000 variable costs of Rs. 63 per unit and revenue Rs. 68 per unit. Annual fixed cost at Location B are Rs. 8,00,000 variable costs are Rs. 32 per unit and revenues are Rs. 68 per unit. Sales volume is estimated to be 25000 units/year, which location is attractive?

Solution:

Location A: BEP (units) =60,000 and Location B: BEP (units) =22,222.

At the expected demand of 25000 units, profits (loss) for the alternatives are:

Alternatives

	A	B
Revenue	1,700,000	1,700,000
Costs:		
Variables	1,575,000	800,000
Fixed	300,000	800,000
	1,875,000	1,600,000
Profit/(Loss)	(175,000)	100,000

Location B is most attractive, even though annual fixed costs are much higher than A.

Problem: 5

A manufacturer is considering four locations for a new plant. It has attempted to study all costs at the various locations and find that the costs of the following items vary from one location to another. The firm will finance the new plant from deposits bearing 10 percent interest.

	A	B	C	D
Labour (Rs. per unit)	0.75	1.10	0.80	0.90
Plant (Rs. crores)	0.46	0.39	0.40	0.48
Materials & equipment * (Rs. per unit)	0.43	0.60	0.40	0.55
Electricity (per year) (Rs.)	30.00	26.00	30.00	28.00
Water (per year) (Rs.)	7.00	6.00	7.00	7.00
Transportation (per unit) (Rs.)	0.02	0.10	0.10	0.05
Taxes (per year) (Rs.)	33.00	28.00	63.00	35.00

* This cost includes a projected depreciation, but no interest.

Determine the most suitable location (economically) for output volumes in the range of 50,000 to 1,30,000 units per year.

Costs	**A**	**B**	**C**	**D**
Fixed Cost (per year) :				
10% of investment	4,60,000	3,90,000	4,00,000	4,80,000
Electricity	30,000	26,000	30,000	28,000
Water	7,000	6,000	7,000	7,000
Taxes	33,000	28,000	63,000	35,000
Total Fixed Cost	5,30,000	4,50,000	5,00,000	5,50,000
Variable Cost :				
Labour	0.75	1.10	0.80	0.90
Material & equipment	0.43	0.60	0.40	0.55
Transportation	0.02	0.10	0.10	0.05
Total Variable Cost (per unit)	1.20	1.80	1.30	1.50
Total Cost:	5,30,000 + 1.2/unit	4,50,000 + 1.8/unit	5,00,000 + 1.3/unit	5,50,000 1.5/unit

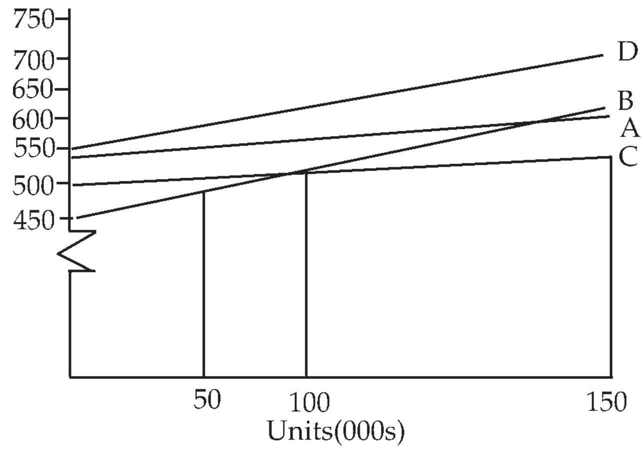
The point for a plant plans location break-even analysis chart are as follows:

At zero unit of output, use fixed cost values. At 100000 units of output:

A = 6,50,000; B = 6,30,000; C = 6,30,000; D = 7,000,000.

Plot the graph of these linear functions.

Solution:



From the graph it is clear that, for minimum cost, use site B for a volume of 50,000 to 1,00,000 units, use site C for a volume of 1,00,000 to 1,30,000 units.

Problem: 6

Mr. X, the factory Manager of S.K.Industries, is considering an interchange of departments 3 and 6 in the present layout. The present layout and the interdepartmental materials handling frequencies are furnished below [All the departments are of the same size and configuration in the following matrix, respectively.]

1	3	5
2	4	6

Present Layout

Weekly frequencies of interdepartmental Material handling

From / To	1	2	3	4	5	6
1	–	0	90	160	50	6
2	–	–	70	0	100	130
3	–	–	_	20	0	0
4	–	–	–	_	180	10
5		–	–	–	–	40

The per unit length inter departmental cost of materials of materials handling are equal. What is the effect of the interchange of the departments 3 and 6 in the layout?

Solution:

The distance matrix for the present layout can be given as follows (Considering only the departments that share a border as adjacent departments).

Distance matrix (for initial layout)

From / To	1	2	3	4	5	6
1	1	1	2	2	3	
2	–	2	1	3	2	
3	–	–	1	1	2	
4	–	–	–	2	1	
5		–	–	–	1	
6	–	–	–	–	–	

The total cost matrix can be easily calculated combining the inter-departmental materials handling frequencies and the distance matrices.

Total cost matrix (for the initial layout)

From / To	1	2	3	4	5	6
1	0	90	320	100	0	510
2		140	0	300	260	700
3			20	0	0	20
4				360	10	370
5					40	40
6						
					Total	1,640

If the department 3 and 6 are interchanged, the layout would be as follows:

1	6	5
2	4	3

From / To	1	2	3	4	5	6
1	–	1	3	2	2	1
2	–	–	2	1	3	2
3	–	–	_	1	1	2
4	–	–	–	_	2	1
5		–	–	–	–	1

From / To	1	2	3	4	5	6	Total
A		0	270	320	100	0	690
B			140	0	300	260	700
C				20	1	0	20
D					360	10	370
E						40	40
F							–
Total							1,820

By interchanging the departments 3 and 6 the total cost has been increased. So it is not advisable.

Problem: 6

A company planning, to manufacture a household cooking range, has to decide on the location of the plant. Three locations are being considered viz., Patna, Ranchi, and Dhanbad. The fixed costs of the three locations are estimated to be Rs. 30 lakh, 50 lakh, and 25 lakh per annum respectively. The variable costs are Rs.300, Rs.200 and Rs.350 per unit respectively.

The expected sales price of the cooking range is Rs.700 per unit find out

(a) the range of annual production/sales volume for which each location is the most suitable and

(b) Which one of the three locations is the best location at a production/sales volume of 18,000 units?

Solution:

The total cost of the three locations are:

At Total cost = Fixed cost + Variable cost for a volume "X"

Patna => Total cost = 30,00,000 + 300 × X

Ranchi => Total cost = 50,00,000 + 200 × X

Dhanbad => Total cost = 25,00,000 +350 ×X

We can compute and plot the total costs per annum at the three different locations for the various cases of production volume of 5000, 10000, 15000, 20000, 25000 units.

a) Patna

Volume (Units)	5,000	10,000	15,000	20,000	25,000
Total	=30,00,000+	30,00,000+	30,00,000+	30,00,000+	30,00,000+
Cost (Rs.)	300(5,000)	300(10,000)	300(15,000)	300(20,000)	300(25,000)
	=Rs.45 lakhs	=Rs.60 lakhs	=Rs.75 lakhs	=Rs.90 lakhs	=Rs.105lakhs

b) Ranchi

Volume (Units)	5,000	10,000	15,000	20,000	25,000
Total	= 50,00,000+	50,00,000+	50,00,000+	50,00,000+	50,00,000+
Cost (Rs.)	200(5,000)	200(10,000)	200(15,000)	200(20,000)	200(25,000)
	=Rs.60	=Rs.70	=Rs.80	=Rs.90	=Rs. 100
	lakhs	lakhs	lakhs	lakhs	lakhs

c) Dhanbad

Volume (Units)	5000	10000	15000	20000	25000
Total	= 25,00,000+	25,00,000+	25,00,000+	25,00,000+	25,00,000+
Cost (Rs.)	350(5,000)	350(10,000)	350(15,000)	350(20,000)	350(25,000)
	=Rs.42.5	=Rs.60	=Rs.77.5	=Rs.95	=Rs.112.5
	1akhs	1akhs	1akhs	1akhs	1akhs

If the volume distribution be as follows:

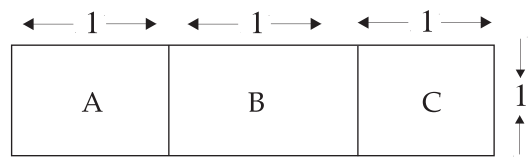
	up to 10,000 unit	between 10,000 units to 20,000 units	above 20,000 units
Favourable Location	Dhanbad	Patna	Ranchi

For a volume 18000 units favourable location is Patna which can be substantiated by the followings:

Patna	=>	30,00,000 +300 × 18000 = Rs. 84 lakhs
Ranchi	=>	50,00,000+200 × 18000 = Rs. 86 lakhs
Dhanbad	=>	25,00,000 +350 × 18000 = Rs. 88 lakhs

Problem: 7

Find an improved layout for the initial layout given in figure by using CRAFT pair wise exchange technique. The interdepartmental flows are also furnished along with the interdepartmental cost matrix.



Initial Layout

Cost Matrix

From \ To	A	B	C
A		1	1
B	1		1
C	1	1	

Flow Matrix

From \ To	A	B	C
A		1	2
B	1		3
C	3	3	

Distance Matrix

From \ To	A	B	C
A		1	2
B	1		1
C	2	1	

Solution:

For the initial layout let us find the total cost matrix (which is the product of the cost flow and distance matrices given).

Total Cost Matrix (Initial)

From \ To	A	B	C	Total
A		1	4	5
B	1		3	4
C	6	3		9
	Total Cost			18

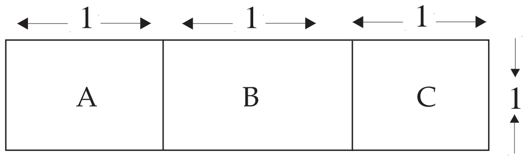
CRAFT considers exchanges between a pair of departments which have

i) either a common border, or ii) the same area.

Since in the given problem, all the three departments A, B and C have the same area they can be interchanged with each other in pairs. The interchanges that are possible are between, (i) A and B, (ii)

A and C, and (iii) B and C.

Let us interchange A and B (Figure).



Initial Layout

The total cost is now more than that for the initial layout and so this exchange is not desirable. We may next try the exchange between A and C. However, this exchange results in only a mirror image of the initial layout. As such, that is not giving to change the total cost, and layout. Therefore we try the next possible exchange, viz., between B and C (Figure).

Distance Matrix

To / From	A	B	C
A		1	1
B	1		2
C	1	2	

Therefore, the total cost matrix will be

Cost Matrix

To / From	A	B	C	Total
A		1	2	3
B	1		6	7
C	3	6		9
	Total Cost =			19

A	C	B

New Layout

New Distance Matrix

The total cost matrix is given below

Total Cost Matrix

To / From	A	B	C	Total
A		2	2	4
B	2		3	5
C	3	3		6
Total	5	5	5	15

This matrix is an improvement over that for the initial layout and is thus accepted. The improved layout flow is shown in figure.

A	C	B

Final Layout

Material Handling System:

Material handling is an integral part of manufacturing process. In order to manufacture any product, it is essential to move the material from one place to that of another. Materials must be turned, moved, and positioned on the respective machines to produce the required output. Materials must also be inevitably moved from one machine to another. Though operators can be employed to move the materials, the common practice is to move the materials from one processing area to another and from one department to another. To start with, material must-be moved, prior to the production process, from the storage room to the first processing operation. There may also be inter-departmental transfer of materials or finned goods from the final conversion operation performed to final inspection. Finally, they go to the finished goods room and then shipped to customers.

In a general sense, materials handling includes all movement of materials in a manufacturing situation. Materials handling is defined as the art and science involving the moving, packing, and storing of substances in any form.

The primary objective of materials handling is to improve production performance by speeding up material flow. Lower unit cost of production less work in progress, reduced labour costs of handling materials, better utilization of shop floor and warehouse, fewer breakages, reduced fatigue of operatives and other shop floor personnel, better facilities and reduced accidents, improved product quality, better customer service, and general safety are the other objectives of the materials handling system. The twin objectives therefore can be:

- Improvement of production performance and reduction of costs.
- Improvement of conditions for shop floor personnel.

These are discussed as under:

- ***Better control of the flow of goods:*** Effective materials handling system results in better control of the flow of goods.
- ***Higher productivity at lower manufacturing cost:*** The material handling system in any manufacturing organization should be primarily designed to improve productivity and avoid inordinate delays in furnishing the required materials at the manufacturing place. The fastest most efficient and economical movement of materials result in higher productivity at lower manufacturing cost.
- ***Improved working conditions and greater safety in the movement of materials:*** The manufacturing organizations are required to follow the safe handling practices. Safe handling of materials limits the cases of industrial accidents and employees feel safe and secure to work in manufacturing units.
- ***Increased storage capacity:*** Scientific movement and storage of materials result in the effective utilization of available storage space.
- ***Lower the unit materials handling costs:*** It is quite obvious that the overall materials handling costs will be reduced if the unit costs are reduced.

- ***Provide for fewer rejects:*** Careful handling of the product will contribute to a better quality level of the goods, produced. Ineffective handling of materials results in breakage, and damage, to the goods produced. Production of defective pieces acts as a major cost to manufactures.
- *Reduce the manufacture cycle time:* Through effective handling of materials, the total time required to make a product move from the receipt of raw materials to the finished goods. Movement of materials can be speeded up or may be handled over shorter distances. Substantial reduction of the manufacturing cycle time will eventually reduce the inventory costs and the other production costs incident thereto.

Principles of Material Handling

Materials handling is a service function; it is not an end in itself. The principles of materials handling can be grouped under three broad headings:

- Principles relating to the elimination of wasteful methods,
- Principles relating to the laying out the plant,
- Principles relating to the selection and application of materials handling equipment.

Wasteful methods can be eliminated by following the undermentioned principles.

- Avoiding the unnecessary transfer of materials from floor to workplace or from container to container,
- Eliminating unnecessary mixing and subsequent storing,
- Increasing the speed of handling the materials,
- Utilizing gravity as a moving force, wherever practicable,
- Introduction of automaticity into the materials handling system,
- Reducing to a minimum the number of handlings of materials,
- Using mechanical aids to eliminate the use of hand labour in the movement of materials.

Principles of Material Handling

Related to Planning
- Planning Principle
- Systems Principle
- Material Flow Principles
- Simplification Principle
- Gravity Principle
- Space Utilisation Principle
- Safety Principle

Related to Equipment
- Mechanisation/ Automation Principle
- Equipment Selection Principle
- Flexibility Principle
- Dead Weight Principle
- Motion Principle
- Idle Time Principle
- Maintenance Principle
- Obsolesence Principle

Related to Operation
- Control Principle
- Capacity Principle
- Performance Principle

Fig. Principles of Material Handling

Selection of Materials handling equipment

The following principles should be borne in mind; while, selecting and applying various materials handling equipment:

- As far as possible, management should avoid; using the complicated mechanisms and controls; it is better, to use the simplest possible equipment to handle the materials.
- Before considering the purchase of new equipment; the activities must be planned and the equipment needs must be analysed.
- Before purchasing the equipment, comparative costs of various equipments must be determined and analysed.
- Different equipment must be used for different jobs.
- Equipment selected for handling materials must be flexible in its application.
- It is necessary that equipment must be managed and maintained properly.
- It is necessary to ensure that obsolete methods and equipment are replaced periodically.
- Management should ensure that the new handling equipment must be put to effective use.
- Management should try to standardize equipment, if possible.
- Selection of equipment should be based on the principle that the equipment should minimize the ratio of mobile equipment dead weights to payloads.
- The building must big enough to keep the materials handling equipment.

Various types of materials handling equipment used in manufacturing organisations:

Materials handling requires some equipment especially designed to meet the requirements of handling different materials. The general types of materials handling equipment include the conveyors, cranes, elevator and hoists; positioning; weighing and control equipment; industrial vehicles motor vehicles; railroad cars; marine carriers; aircraft; containers and supports. The main types of equipment can be conveniently classified under the following heads;

- Aerial ropeways and cable-ways
- Conveyors: These include
  (i) Chutes
  (ii) Roller Conveyors
  (iii) Belt conveyors
  (iv) Drag lines
  (v) Bar or slot
  (vi) Tow
  (vii) Screw
  (viii) Pneumatic.
  (ix) Bracket or tray elevators
  (x) Car and chair conveyors

(xi) Monorails

The conveyors are expensive to install, but cheap to run. Further, they are reliable in operation. Most of the conveyors are inflexible and restrict plant layout changes. They have one positive advantage - they require little maintenance.

- Hoists and lifts
- Cranes: Actually, it is very difficult to precisely define cranes as they shade in one direction into hoists and in the other direction into conveyors. Several possibilities could be:

  (i) Portable or mobile

  (ii) Fixed track travelling

  (iii) Fixed

  (iv) Other sub-types including the job, gantry, bridge, and derrick.
- Trucks and tractors: These include

  (i) Straddle

  (ii) Pedestrian controlled

  (iii) Hand operated

  (iv) Industrial tractors
- Pallet handling trucks and pallets: A pallet is a portable platform on which goods are placed to form a 'unit' load for handling and stacking. A variety of trucks has been designed for handling pallets, including the following:

  (i) Forklift trucks: A generic term covering all types of trucks capable of using forks to lift pallets.

  (ii) Reach trucks: These are used where the forks are telescopic to facilitate stacking.

  (iii) Stackers: These are designed in such a way that they can be operated from batteries or mains in a fixed position.

  (iv) Hand pallet trucks

  (v) Stillage trucks: A stillage is a simple form of pallet, usually disposable and therefore cheaply constructed. Stillage trucks are usually hand-operated trucks.

  The devices that can be used with forklift trucks include:

  (i) Side shifter attachments for correct lateral positioning,

  (ii) Special loading and off-loading attachments,

  (iii) Clamping arms and grabs,

  (iv) Tilting, rocking and rollover devices.
- Earth moving equipment: These are of little concern in material handling.
- Various miscellaneous equipment: These include:

  (i) Lorry floor conveyors,

(ii) Van loader,

(iii) Lorry loader,

(iv) Lifting tail gates,

(v) Vibrating screens,

(vi) Hydraulic bridges.

- Automatic transfer equipment: The quest for automation has resulted in rapid development of automatic transfer equipment in the recent past.

Factors affecting the selection of materials handling equipment:

The primary objective of employing the materials handling equipment is to arrive at the lowest cost per unit of material handled. This entails attaining a happy balance between the production problem, the capabilities of the equipment available, and the people involved in using the equipment. The factors concerning the production problem include the volume of production, the types and classes of materials needed, the layout of the plant and building premises. The factors to be taken into account while employing the equipment for handling the materials includes:

- ***Adaptability:*** The load-carrying and movement characteristics of the equipment selected should fit the materials handling problem.
- ***Cost:*** The most important factor in the selection of materials handling equipment is the cost of the equipment. The cost must not be prohibitive; rather it should be reasonable. A manager should consider several factors here; the initial purchase price, direct and indirect labour required in operating the equipment, installation costs, maintenance costs, power requirements, insurance requirements, space requirements, depreciation charges, salvage value, time value of money invested, and any other costs, that are to be incurred in future of course, it is expected that the anticipated annual savings from installing the materials handling equipment must exceed the total annual costs of investment.
- ***Ease of maintenance:*** The maintenance of equipment selected and purchased at reasonable cost is another important factor.
- ***Environment:*** Equipment selected must conform to the environmental requirements of an organization.
- ***Flexibility:*** It is better if the equipment selected is flexible enough to handle more than one type of material.
- *Power:* Enough power should be available to do the job.
- ***Space requirements:*** While selecting the equipment space required to install shall have to be taken into account.
- ***Speed:*** Within the limits of the production process of plant safely, materials must be moved at a reasonable speed.
- ***Supervision:*** Depending on the degree of automaticity, supervision must be exercised on the machines installed to handle the materials.
- ***The load capacity:*** The load capacity of the selected equipment must be adequate enough to perform the job effectively. However, the equipment should not be too heavy and result in excessive operating costs.

STUDY NOTE - 2

Production Planning and Productivity Management

2.0 Time Study, Work Study, Method Study & Job Evaluation

Time Study:

Time study is defined to be a searching scientific analysis of the methods and equipment used or planned in doing a piece of work, development in practical detail of the best manner of doing it and determination of the time required.

Operation analysis is the study of the entire process to determine whether operations can be eliminated, combined or the sequence changed. Operation analysis aims to determine the one best way and can be applied to method, materials, tools equipment layout, working conditions and human requirements of each operation.

Job standardisation consists in determining the one best way of performing a job under the means at command of recording the exact method along with the time for each element of operation and establishing means to maintain the standard conditions.

Another term connected with time and motion study is the job analysis. Job analysis is the determination of essential factors in a specific kind of work and of the qualifications of a worker necessary for its performance.

Time study aims at determining the best manner of doing a job and timing the performance of the job when done in the best manner.

In motion study the work is divided into fundamental motions and in time study work is divided into elements of operations. In both cases attempts are made to remove useless motions and improve combination and sequences of motions and operations. In motion study the best way of doing a work is determined by motion analysis and operators are trained to follow the method so determined but in time study the best method is determined by analysis of the methods and equipment, used and motions only roughly considered and that too indirectly. In time study, setting of production standards, standards for cost purposes and wage incentives are emphasised. The measurement of human effort is a difficult job which can only be solved by using scientific method and industrial experience combined with knowledge of psychology.

The use of scientific method involves experiment measurement and elimination of variables connected with a job.

The variables connected with a job are the method of manufacture, tools and equipments, material, working conditions, worker concerned and time required to perform the job. In order to measure the last variable time, the other variables must be eliminated by standardising. In going to proceed for time study, it is first necessary to standardise the method and conditions of work and to define what an average worker is. Time study has two sides, mechanical and human.

Before commencing the time study, the time study man should ensure and ascertain the following:

- That motion studies have been carried out so that planning of work, work places and appliances are satisfactory.
- That the operations can be performed in the correct; sequence without interruption.
- That the human effort involved is minimum.
- That the worker in question has average skill and diligence necessary for the work.

Work Study:

It is a general term for the techniques: methods study and work measurement which are used in the examination; of human work in all its contexts and systematically investigate all factors leading to improvement of efficiency.

Work study aims at finding the best and most efficient way of using the available resources—men, materials, money and machinery. Once the method study has developed an improved procedure for doing a work the work measurement or time study will study the time to complete a job.

Method Study:

It is the systematic investigation of the existing method of doing a job in order to develop and install an easy, rapid, efficient, effective and less fatiguing procedure for doing the same job and at minimum cost. This is achieved by eliminating unnecessary motions involved in a certain operation or by changing the sequence of operation or the process itself.

Methods study can be made by the help of both motion study and time study.

The methods study programme must include the following features:–

(a) Uniform application,

(b) Established standard practice,

(c) Continuous review,

(d) Credit distribution.

A new and improved method developed in one department should be spread out to the entire plant preferably with further improvements.

A new method must not be forgotten between orders as it happens sometimes in batch production. Methods department should always aim at improved and better ways of doing jobs.

For successful control of methods study, the enthusiastic cooperation of every employee is required. To gain employee cooperation, distribution of credit is essential. It has been correctly said that a good methods department rarely takes credit for an original idea. Its success lies in getting new ways and methods adopted promptly, universally, continuously and cooperatively towards the improvement of productivity.

Job Evaluation:

Job evaluation is the ranking grading, and weighing of essential work characteristics of all jobs in order to find out or rate the worth of jobs. It is a systematic approach to ascertain the labour worth of each job and is a very important concern of all employers.

Job evaluation aims at fairness and consistency so far as all wages and salaries are concerned within an organisation and when systematic and impartial, it stimulates, confidence of the employees. There are three steps for evaluations of all jobs :–

(i) Preparation of preliminary description of each existing job.

(ii) Analysing each job to arrive at final job descriptions and specifications.

(iii) Analysing each job according to its approved description in order to determine its worth or value.

Job Description and Specifications: The understanding of the job content or job description is the primary requirement.

Job specifications are derived from the job descriptions which have already been approved. The specification help determining the qualification required of the individual desired for the position. This in turn guides the personnel department in the selection of employees and also guides shop executives in the placement of workmen.

Systems of Valuation**:** There are several systems of job evaluation.

The fundamental criteria in valuation of a job into account are to make a specific list of factors which affect job values. The many factors are:

(i) Qualifications required of the worker,

(ii) Job difficulties,

(iii) Job responsibilities,

(iv) Working conditions.

All these factors are to be analysed in detail in order to complete the job description. The list of factors, the manner in which they are apprised and the method of finding out relative worth and money values distinguishes the various systems of valuation.

The systems of valuations which are commonly adopted are given below:

1. The ranking or grading method,
2. The factor comparison method,
3. Point rating method.

Ranking or Grading Method: Under this system the titles of all jobs are written on cards and the grading is done by several competent judges. The hourly rates to be paid for different jobs are suggested by the judges without any consideration to the existing wage. The ranks or grades assigned to each job by all the judges are averaged and this average is considered the "score" for that job. Hourly rates are then fixed for jobs according to their ranking.

Factor Comparison Method: The factor comparison method analyses the job into much greater detail than the grading method. It ranks each job with respect to each factor that characterise the job and the factors are taken one at a time.

All jobs are compared and ranked first with respect to mental requirements, then skill, then physical requirements and after that responsibility and lastly working conditions. The total worth of the job is obtained by adding together money values which are assigned separately to the various levels of rank in each factor. Factor comparison method is more accurate than the simple ranking systems, since the separate factors are analysed comparatively. This method is flexible.

Point Rating Method: There are three methods of analytical evaluation of a job. They are:

1. Straight point method.
2. Weighted point method.
3. Valuation of jobs directly in money method, not specifying any maximum weight.

Straight Point Method: This method assigns equal weights for each characteristic. When evaluating a job under this system, it is assumed that all the characteristics have ranges of values between same maximum and minimum points.

Weighted Point Method: In this method different points are assigned to the different characteristics of doing jobs.

Direct to Money Methods: After selecting the job characteristics, ten key jobs whose rates are believed to be correct, are taken and the present wage rates of these jobs are distributed to the job characteristics by each analyst. The jobs are then ranked by the analysts for each characteristic in order of the degree to which that characteristic is present. This serves as a check to show up any errors made in the original distribution of the wages rate to the various characteristics.

Problems and Solutions

Problem: 1

Continuous stopwatch study observations for a job are given. Compute the standard time for the job, if the total allowances are 15%.

Ele. No.	**Description**	**Cycle time (min)**										**P.R.**
		1	2	3	4	5	6	7	8	9	10	
A	Loosen vice	0.09	0.49	0.89	1.31	1.70	2.09	2.50	2.88	3.29	3.71	90
B	Set bar length	0.16	0.56	1.38	1.38	1.76	2.16	2.57	2.95	3.36	3.78	110
C	Switch m/c	0.28	0.67	1.49	1.49	1.88	2.28	2.68	3.07	3.40	3.90	120
D	Unlock arm & set saw	0.41	0.80	1.61	1.61	2.00	2.41	2.80	3.20	3.62	4.03	100

Solution:

The individual element cycle timing is computed from the cumulative cycle times as shown in table below:

Ele. No.	**Cycle time (min)**										**Avg. time**	**Normal time**
	1	2	3	4	5	6	7	8	9	10		
A	0.09	0.08	0.09	0.10	0.09	0.09	0.09	0.08	0.09	0.09	0.089	0.080
B	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.068	0.075
C	0.12	0.11	0.12	0.11	0.12	0.12	0.11	0.12	0.13	0.12	0.118	0.142
D	0.13	0.13	0.14	0.12	0.12	0.13	0.12	0.13	0.13	0.13	0.128	0.128
											Total	0.425

Standard time = $\frac{0.425}{1-0.15}$ = 0.500 minutes.

Problem: 2

The work - study engineer carries out the work sampling study. The following observations were made for a machine shop.

Total number of observations	7000
No. Working activities	1200
Ratio between manual to machine elements	2:1
Average rating factor	120%
Total number of jobs produced during study	800 units
Rest and personal allowances	17%

Compute the standard time for the job.

Solution:

(i) Overall time per unit (To) $= \dfrac{\text{Duration of study}}{\text{Number of jobs produced during study}} = \dfrac{120 \times 60}{800} = 9$ min.

(ii) Effective time per piece (Te) = To × $\dfrac{\text{Productive observations}}{\text{Total observations}} = 9 \times \dfrac{5800}{7000} = 7.46$ min.

The effective time is to be segregated into manual time and machine element time.

Machine controlled time per piece (Tm) = 7.46 × 1/3 = 2.49 min

Hand controlled time per piece (Th) = 7.46 × 2/3 = 4.97 min

Normal time per piece = Tm + Th × performance rating = 2.49 + 4.97 × 1.2 = 8.46 min.

Standard time per piece = 8.46 (1 + 0.17) = 9.9 minutes.

Problem: 3

The time study of a machinery operation recorded cycle times of 8.0, 7.0, 8.0 and 9.0 minutes. The analyst rated the observed worker as 90%. The firm uses a 0.15 allowance fraction. Compute the standard time.

Solution:

Average cycle time $= \dfrac{8.0 + 7.0 + 8.0 + 9.0}{4} = 8.0$ minutes.

Normal time = 8.0 × 0.9 = 7.2 minutes.

Standard time $= \dfrac{7.2}{(1-0.15)} = 8.47$ minutes.

The standard time for this machinery operation would be set at 8.47 minutes, which is greater than the average cycle time observed. The average cycle time was adjusted for the rating factor (90%) and the allowance fraction (0.15).

Problem: 4

An analyst wants to obtain a cycle time estimate that is within ± 5% of the true value. A preliminary run of 20 cycles took 40 minutes to complete and had a calculated standard deviation of 0.3 minutes. What is the coefficient of variation to be used for computing the sample size for the forthcoming time study?

Solution:

Standard deviation of sample(s) = 0.3 min/cycle.

$$\text{Mean of sample} = \bar{x} = \frac{40 \ \text{min}}{20 \ cycle} = 2 \text{ min./cycle;}$$

$$V = \frac{s}{\bar{x}} = \frac{0.3}{2} = 0.15$$

Problem: 5

A job has been time standard for 20 observations. The mean actual time was 5.83 minutes and the standard deviation of the time is estimated to be 2.04 minutes. How many total observations should be taken for 95% confidence that the mean actual time has been determined within 10%?

Solution:

$$n = \left(\frac{Zs}{A\bar{x}}\right)^2 = \left[\frac{1.96(2.04)}{0.10(5.83)}\right]^2 = 47$$

Therefore, a total of 47 observations should be made. Since 20 observations have already been made, only 27 more are necessary.

Problem: 6

An analyst has observed a job long enough to become familiar with it and has divided it into five elements. The element times for the first four cycles and a performance rating for each element are given in the following table,

Element	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Performance Rating (%)
1	1.246	1.328	1.298	1.306	90
2	0.972	0.895	0.798	0.919	100
3	0.914	1.875	1.964	1.972	100
4	2.121	2.198	2.146	2.421	110
5	1.253	1.175	1.413	2.218	100

(a) Do any of the times look like outliners, i.e. probable errors in reading or recording data that should not be included in the analysis?

(b) Compute an estimated normal time for the job based on the data available at this stage of the study.

(c) On the basis of the data available, what sample size should be taken to estimate the time for element 2 within 5% of the true mean time with 95% confidence?

Solution:

(a) The times for element 3 in cycle 1 and for element 5 in cycle 4 are suspect and should be disregarded.

(b) The following estimates are made on the basis of the remaining times

Element	Mean actual time	Performance Rating (%)	Normal time
1	1.295	90	1.116
2	0.896	100	0.896
3	1.937	100	1.937
4	2.222	110	2.444
5	1.28	100	1.28

Normal time for total job = 7.723

(c) For element 2:

$\bar{x}$ = 0.896

$$S = \sqrt{\frac{\sum x^2 - \frac{\left(\sum x\right)^2}{n'}}{n'-1}} = \sqrt{\frac{3.227174 - \frac{(3.584)^2}{4}}{3}} = 0.0728$$

$$n = \left(\frac{Zs}{A\bar{x}}\right)^2 = \left[\frac{1.96(0.0728)}{0.05(0.896)}\right]^2 = 10.14$$

The analyst probably would want to use more than 10 observation, so that workers would have more confidence in the standard. A Company might make it a general practice to use at least say 15 or more observations.

Problem: 7

Stopwatch time study figure for a job which is continuous in nature are given below. Calculate the Standard Time for the job assuming that the sample size is adequate, and total allowances are 15 percent.

Ele. No.	Description per cycle	Cycle time (min)										P.R.
		1	2	3	4	5	6	7	8	9	10	
1	A	0.10	0.50	0.90	1.32	1.71	2.10	2.51	2.89	3.30	3.72	90
2	B	0.17	0.57	0.96	1.39	1.77	2.17	2.58	2.96	3.37	3.79	110
3	C	0.29	0.68	1.08	1.50	1.89	2.29	2.69	3.08	3.41	3.91	120
4	B	0.15	0.81	1.22	1.62	2.01	2.42	2.81	3.21	3.63	4.04	100

Solution:

From the continuous study figure the individual time figures are derived.

Ele. No.	Description per cycle	Cycle time (min) 1	2	3	4	5	6	7	8	9	10	Arithmetic Average	Normal time of element (min)
1	A	0.10	0.08	0.09	0.10	0.09	0.09	0.09	0.08	0.09	0.09	0.090	0.081
2	B	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.07	0.07	0.07	0.068	0.075
3	C	0.12	0.11	0.12	0.11	0.12	0.12	0.11	0.12	0.13	0.12	0.118	0.142
4	D	0.13	0.13	0.14	0.12	0.12	0.13	0.12	0.13	0.13	0.13	0.128	0.128

Total time = 0.426 min

Standard time = 0.426 ÷ (1 - 0.15) = 0.501 min

2.1 Production Planning and Control Introduction

Production planning control can be viewed as the nervous system of a production operation. The primary concern of production planning and control is the delivery of products to customers or to inventory stocks according to some predetermined schedule. All the activities in the manufacturing or production cycle must be planned, coordinated, organised, and controlled to achieve this objective. From a long-term point of view (usually from seven to ten years or more) production planning largely deals with plant construction and location and with product-line, design and development. Short-range planning (from several months to a year) focuses on such areas as inventory goals and wage budgets. In plans projected over a two-to-five year period, capital-equipment budgeting and plant capacity and layout are the major concern. Production planning and control normally reflects the short range activities and focuses on the issues and problems that arise in the planned utilisation of the labour force, materials, and physical facilities that are required for manufacturing the products in accordance with the primary objectives of the firm.

Production systems are usually designed to produce a variety of products and are, therefore, complex. In such complex systems, anything can happen and usually it is so. Therefore, it is vital to exercise some kind of control over the production activities. Control is possible only when everything is planned. Production planning and control is thus a very important aspect of production management.

Objectives of production planning and control

The ultimate objective of production planning and control is to contribute to the profits of the enterprise. This is accomplished by keeping the customers satisfied through the meeting of delivery schedules. Further, the specific objectives of production planning and control are to establish the routes and schedules for work that will ensure the optimum utilisation of raw materials, labourers, and machines to provide the means for ensuring the operation of the plant in accordance with these plans. Production planning and control is essentially concerned with the control of work-in-process. To control work-in-process effectively it becomes necessary to control not only the flow of material but also the utilisation of people and machines.

Production planning and control fulfils these objectives by focusing on the following points:

- Analysing the orders to determine the raw materials and parts that will be required for their completion,
- Answering questions from customers and salesmen concerning the status of their orders,

- Assisting the costing department in making cost estimates of orders,
- Assisting the human resource departments in the manpower planning and assignment of men to particular jobs,
- Controlling the stock of finished parts and products,
- Determining the necessary tools required for manufacturing,
- Direction and control of the movement of materials through production process,
- Initiating changes in orders as requested by customers while orders are in process,
- Issuing requisitions for the purchase of necessary materials,
- Issuing requisitions for the purchase or manufacture of necessary tools and parts,
- Keeping the up-to-date records scheduled and in process,
- Maintaining stocks of materials and parts,
- Notifying sales and accounting of the acceptance of orders in terms of production feasibility,
- Preparing the route sheets and schedules showing the sequence of operation required to produce particular products,
- Production of work orders to initiate production activities,
- Receiving and evaluating reports of progress on particular orders and initiating corrective action, if necessary,
- Receiving orders from customers,
- Revising plans when production activities cannot conform to original plans and when revisions in scheduled production are necessary because of rush orders.

Production control involves the following functions:

- Planning the production operations in detail,
- Routing, i.e., laying down the path for the work to follow and the order in which the various operations will be carried out,
- Scheduling, i.e., establishing the quantity of work to be done, and fixing the time table for performing the operations,
- Dispatching, i.e., issuing the necessary orders, and taking necessary steps to ensure that the time targets set in the schedules are effectively achieved,
- Follow-up, taking necessary steps to check up whether work proceeds according to predetermined plans and how far there are variances from the standards set earlier,
- Inspection, i.e., conducting occasional check-ups of the products manufactured or assembled to ensure high quality of the production.

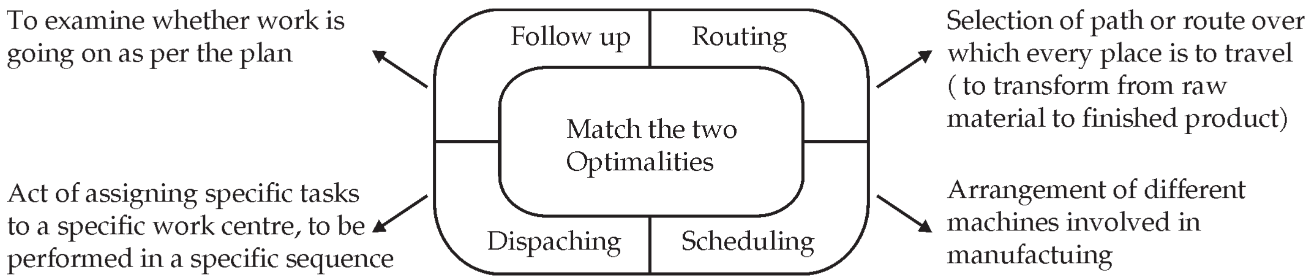


Figure : Techniques of Production Control

Basic types of production control:

Production control can be of six types:

- ***Block control***

  This type of control is most prominent in textiles and book and magazine printing. In these industries it is necessary to keep things separated and this is the fundamental reason why industries resort to block control.

- ***Flow control***

  This type of control is commonly applied in industries like chemicals, petroleum, glass, and some areas of food manufacturing and processing. Once the production system is thoroughly designed, the production planning and control department controls the rate of flow of work into the system and checks it as it comes out of the system. But, under this method, routing and scheduling are done when the plant is laid out. That is to say, the production line which is established is well balanced and sequenced before production operations begin; this type of control is more prevalent in continuous production systems.

- ***Load control***

  Load control is typically found wherever a particular bottleneck machine exists in the process of manufacturing.

- ***Order control***

  The most, common type of production control is called order control. This type of control is commonly employed in companies with intermittent production systems, the so-called job-lot shops. Under this method, orders come into the shop for different quantities for different products. Therefore, production planning and control must be based, on the individual orders.

- ***Special project control***

  Special production control is necessary in certain projects like the construction of bridges, office buildings, schools, colleges, universities, hospitals and any other construction industries. Under this type of control, instead of having sets of elaborate forms for tooling and scheduling, a man or a group of men keeps in close contact with the work.

- ***Batch control***

  Batch control is another important, type of production control which is frequently found in the food processing industries. Thus, production control in batch-system of control operates with a set of ingredients that are proportionally related and handled one batch at a time.

Production planning and control in continuous-production systems.

Production systems may be continuous or intermittent. The continuous production systems are characterised by:

- Fixed-path material handling equipment,
- High volume of production,
- Product layouts,
- Production of standardised products,
- Production to stock or long-range orders,
- The use of special-purpose machines or automation.

Production planning and control in continuous-production systems involve two activities:

- Assuring that supply of raw materials and supplies are on hand to keep the production system supplied and assuring that finished products are moved from the production-system,
- Maintaining a constant rate of flow of the production, so that the system can operate near capacity in some case or can meet the quantity requirements of the production.

Production planning in intermittent production systems:

The intermittent production systems are characterized by the following:

- General purpose production machines are normally utilised and process layout is favoured.
- Materials handling equipment is typically of the varied path type such as hand trucks and forklift trucks.
- Relatively high cost, skilled labour is needed to turn out the various quantities and types of products.
- The company generally manufactures a wide variety of products; for the majority of items, sales volumes and consequently production order sizes are small in relation to the total production.

Problems and Solutions

Problem: 1

Machines K and L, both capable of manufacturing an industrial product, compare as follows:

	Machine K	Machine L
Investment	Rs. 60,000	Rs. 1,00,000
Interest on borrowed capital	15%	15%
Operating cost (wages, power, etc.) per hour	Rs. 12	Rs. 10
Production per hour	6 pieces	10 pieces

The factory whose overhead costs are Rs. 1,20,000 works effectively for 4,000 hours in 2 shifts during the year. (i) Justify with appropriate calculations which of the two machines you would choose for regular production. (ii) If only 4000 pieces are to be produced in a year, which machine would give the lower cost per piece. (iii) For how many pieces of production per year would the cost of production be same on either machine? (For above comparisons, the cost of material may be excluded as being the same on both machines.)

Solution:

	Machine K	**Machine L**
Annual interest charges	(Rs. 60,000 x 15) / 100	(Rs. 1,00,000 x 15) / 100
(fixed cost)	= Rs. 9,000	= Rs. 15,000
Annual operating charges	4,000 x 12	4,000 x 10
	= Rs. 48,000	= Rs. 40,000
Total annual charges	= Rs. 57,000	= Rs. 55,000
Annual output	= 4,000 x 6 = 24,000	= 4,000 x 10 = 40,000
Cost per unit	= 5,700 / 2,400	= 55,000 / 40,000
	= Rs. 2.375	= Rs. 1.375

(i) Thus machine L should be chosen for regular production.

(ii) If only 4,000 pieces are to be produced in a year

Interest cost	Rs. 9,000	Rs. 15,000
Operating cost	(4,000 / 6) x 12 = Rs. 8,000	(4,000 / 10) x 10 = Rs. 4,000
Total cost	= Rs. 17,000	= Rs. 19,000
Cost per unit	(17,000 / 4,000) = Rs. 4.25	(19,000 / 4,000) = Rs. 4.75

Thus, machine K gives the lower cost per piece.

(iii) Interest charge	= Rs. 9,000	= Rs. 15,000
Operating cost per piece	= 12 / 6 = 2	= 10/10 = Re. 1

Let the production be = X units,

Then 2X + 9,000 = X + 15,000 or, 2X – X = 15,000 – 9,000 or, X = 6,000 pieces.

For 6,000 piece of production per year the cost of production will be the same (Rs. 21,000) on either machine.

Problem: 2

A department of a company has to process a large number of components/month. The process equipment time required is 36 minutes/component, whereas the requirement of an imported process chemical is 1.2 litres/component. The manual skilled manpower required is 12 minutes/component for polishing and cleaning. The following additional data is available:

	Availability/month	Efficiency of utilisation
Equipment hour	500	85%
Imported chemicals	1000	95%
Skilled manpower - hours	250	65%

(i) What is the maximum possible production under the current conditions? (ii) If skilled manpower availability is increased by overtime by 20%, what will be the impact on production increase?

Solution:

(i) Actual Equipment Hrs. used = 500 × 85/100 = 425 Hrs.

Possible output = 425 × (60/36) = 708 Components

(ii) Imported chemicals = 1,000 × 95/100 = 950 litres, actually used;

Possible output = 950/1.2 = 792 Components

(iii) Skilled manpower Hrs. used = 250 × 65/100 = 162.5 Hrs.

Possible output =162.5 × (60/12) = 813 Components

The bottleneck capacity = 708 Components.

(1) Maximum possible production under the given conditions = 708 Components.

(2) There will be no impact on production increase if skilled manpower is increased by overtime by 20% as the bottleneck in output is equipment hours.

Problem: 3

A manufacturing enterprise has introduced a bonus system of wage payment on a slab-rate based on cost of production towards labour and overheads.

The slab-rate being

1% - 10%	saving in production cost	5% of saving
Between 11%-20%	saving in production cost	15%
Between 21%-40%	saving in production cost	30%
Between 41%-70%	saving in production cost	40%
Above 70%	saving in production cost	50%

The rate per hour for three workers A, B, C are Rs. 5, Rs. 5.50 and Rs. 5.25 respectively. The overhead recovery rate is 500% of production wages and the material cost is Rs. 40 per unit. The standard cost of production per unit is determined at Rs. 160 per unit.

If the time taken by A, B, C to finish 10 units is 26 hours, 30 hours and 16 hours respectively, what is the amount of bonus earned by the individual workers and actual cost of production per unit?

Solution:

	A	B	C
Unit produced	10	10	10
Wage rate	5.00	5.50	5.25
Time taken	26 hours	30 hours	16 hours
Wage payable	130.00	165.00	84.00
Overhead recovery	650.00	825.00	420.00
Materials	400.00	400.00	400.00
Total cost of production	1,180.00	1,390.00	904.00
Standard cost of production	1,600.00	1,600.00	1,600.00
Saving in cost of production	420.00	210.00	696.00
% of savings	26.25%	13.13%	43.50%
Bonus slab	30%	15%	40%
Bonus Amount	126.00	31.50	278.40
Actual cost of production	1,306.00	1,421.50	1,182.40
Cost/unit (Rs.)	130.60	142.15	118.24

Problem: 4

Calculate the break-even point for the following:

Production Manager of a unit wants to know from what quantity he can use automatic machine against semi-automatic machine.

Data	Automatic	Semi-automatic
Time for the job	2 mts	5 mts
Set up time	2 hrs	1.5 hrs
Cost per hour	Rs. 20	Rs. 12

Solution:

Let x be the break-even quantity between automatic and semi-automatic machines. This means, for volume of output V, the total cost of manufacture is the same on both automatic and semi-automatic machines.

For quantity = x units

Total manufacturing cost on automatic machines $= \left(2.0 + \frac{2x}{60}\right) \times 20$ Rs.

Total manufacturing cost on semi-automatic machines $= \left(1.5 + \frac{5x}{60}\right) \times 12$ Rs.

If 'x' is the break-even quantity, then

$$\left(2.0+\frac{2x}{60}\right)\times 20=\left(1.5+\frac{5x}{60}\right)\times 12$$

$$40+\frac{2x}{60}\times 20=18+\frac{5x}{60}\times 12$$

$$40+\frac{2x}{3}=18+x$$

$$x-\frac{2x}{3}=40-18=22$$

$$\frac{x}{3}=22$$

x = 66 units

Hence for quantity upto 65, a semi-automatic machine will be cheaper. For quantity 66, both semi-automatic and automatic machines are equally costly. For quantity more than 66, automatic machine becomes cheaper than semi-automatic machine.

Problem: 5

Two alternative set-ups, A and B are available for the manufacture of a component on a particular machine, where the operating cost per hour is Rs. 20/-.

	Set-up A	**Set-up B**
Components/set-up	4,000 pieces	3,000 pieces
Set-up cost	Rs. 300/-	Rs.1,500/-
Production rate/hour	10 pieces	15 pieces

Which of these set-ups should be used for long range and economic production?

Solution:

Considering one set-up

	Set-A	**Set-up B**
Set-up cost per year	Rs. 300/-	Rs. 1,500/-
Operating hours / set-up	$\frac{4000}{10}$ = 400 hours	$\frac{3000}{15}$ = 200 hours
Operating cost	400 x 20 = Rs. 8,000	200 x 20 = Rs. 4,000
Total manufacturing cost	300 + 8,000 = Rs. 8,300	1,500 + 4,000 = Rs. 5,500
Manufacturing cost per piece	$\frac{8300}{4000}$ = Rs. 2.075	$\frac{5500}{3000}$ = Rs. 1.833

Assuming that the machine is used for production for one year having 2,000 hours of working. For annual production,

	Set-up A	Set-up B
No. of set-ups	$\frac{2000}{400} = 5$	$\frac{2000}{200} = 10$
Set-up cost per year	5 x 300 = Rs. 1,500	10 x 1,500 = Rs. 15,000
No. of units produced per year	2,000 x 10 = Rs. 20,000	2,000 x 15 = Rs. 30,000
Total annual manufacturing cost	1,500 + 40,000 = Rs. 41,500	15,000 + 40,000 = Rs. 55,000
Manufacturing cost per unit	$\frac{8300}{4000}$ = Rs. 2.075	$\frac{5500}{3000}$ = Rs. 1.833

Since the manufacturing cost for set B is less, use set-up B for long range and economic production.

2.2 Forecasting

Forecasting means peeping into the future. As future is unknown and is anybody's guess but the business leaders in the past have evolved certain systematic and scientific methods to know the future by scientific analysis based on facts and possible consequences. Thus, this systematic method of probing the future is called forecasting. In this way forecasting of sales refers to an act of making prediction about future sales followed by a detailed analysis of facts related to future situations and forces which may affect the business as a whole.

Foresight is not the whole of management, but at least it is an essential part of management and accordingly, to foresee in this context means both to assess the future and make provisions for it, that is forecasting is itself action already. Forecasting as a kind of future picture wherein proximate events are outlined with some distinctness, while remote events appear progressively less distinct and it entails the running of the business as foresee and provide means to run the business over a definite period.

As far as the marketing manager is concerned the sales forecast is an estimate of the amount of unit sales for a specified future period under the proposed marketing plan or program. It may also be defined as an estimate of sales in rupees of physical units for a specified future period under a proposed marketing plan or program and under an assumed set of economic and other force outside the organisation for which the forecast is made.

When we consider the function of production and operations management, no doubt Production and Operation departments will produce goods as per the sales program given by the sales department, but it has to prepare forecast regarding machine capacity required, materials required and time required for production and so on. This needs the knowledge of what exactly happened in the production shop in previous periods.

Making of a proper forecast requires the assessment of both controllable and uncontrollable factors (both economic and non economic) inside and outside the organisation.

All business and industrial activities revolve around the sale and its future planning. To know what a business will do we must know its future sales. So, sales forecasting is the most important activity in the business because all other activities depend upon the sales of the concern. Sales forecasting as a guiding factor for a firm because it enables the firm to concentrate its efforts to produce the required quantities, at the right time at reasonable price and of the right quality. Sales forecasting is the basis of planning the various activities i.e.; production activities, pricing policies, programme policies and strategies, personnel policies as to recruitment, transfer, promotion, training, wages etc.

The period of forecasting, that is the time range selected for forecasting depends on the purpose for which the forecast is made. The period may vary from one week to some years. Depending upon the period, the forecast can be termed as 'Short range forecasting', medium range forecasting' and 'Long range forecasting'. 'Short range forecasting period may be one week, two weeks or a couple of months. Medium range forecasting period may vary from 3 to 6 months. Long range forecasting period may vary from one year to any period. The objective of above said forecast is naturally different.

In general, short term forecasting will be of more useful in production planning. The manager who does short range forecast must see that they are very nearer to the accuracy.

In long range forecast, the normal period used is generally 5 years. In some cases it may extends to 10 to 15 years also. The purpose of long range forecast is:

(i) To work out expected capital expenditure for future developments or to acquire new facilities,

(ii) To determine expected cash flow from sales,

(iii) To plan for future manpower requirements,

(iv) To plan for material requirement,

(v) To plan for Research and Development. Here much importance is given to long range growth factor.

In case of medium range forecasting the period may extend over to one or two years. The purpose of this type of forecasting is:

(i) To determine budgetary control over expenses,

(ii) To determine dividend policy,

(iii) To find and control maintenance expenses,

(iv) To determine schedule of operations,

(v) To plan for capacity adjustments.

In case of short-term forecast, which extends from few weeks to three or six months and the following purposes are generally served:

(i) To estimate the inventory requirement,

(ii) To provide transport facilities for finished goods,

(iii) To decide work loads for men and machines,

(iv) To find the working capital needed,

(v) To set-up of production run for the products,

(vi) To fix sales quota,

(vii) To find the required overtime to meet the delivery promises.

Everyone who use the forecast for one purpose or the other expects that they need that forecast should be accurate. But it is practically impossible to forecast accurately. But decisions are made everyday to run the business by using the best information available with them. Management scientists have developed various methods for forecasting. One has to decide which method has to be used to suit the information available with him and to suit his needs. The manager, who is concerned with forecasting, must have knowledge of factors influencing forecast. Various factors that influence the forecast are:

(i) Environmental changes,

(ii) Changes in the preference of the user,

(iii) Number of competitive products,

(iv) Disposable income of the consumer.

In forecasting the production important factors to be considered are:

(i) Demand from the marketing department,

(ii) Rate of labours absenteeism,

(iii) Availability of materials,

(iv) Available capacity of machines,

(v) Maintenance schedules,

(vi) Delivery date schedules.

Steps in forecasting

Whatever may be the method used for forecasting, the following steps are followed in forecasting.

(a) Determine the objective of forecast: What for you are making forecast? Is it for predicting the demand? Is it to know the consumer's preferences? Is it to study the trend? You have to spell out clearly the use of forecast.

(b) Select the period over which the forecast will be made? Is it long-term forecast or medium-term forecast or short-term forecast? What are your information needs over that period?

(c) Select the method you want to use for making the forecast. This method depends on the period selected for the forecast and the information or data available on hand. It also depends on what you expect from the information you get from the forecast. Select appropriate method for making forecast.

(d) Gather information to be used in the forecast. The data you use for making forecasting to produce the result, which is of great use to you. The data may be collected by:

  (i) Primary source: This data we will get from the records of the firm itself.

  (ii) Secondary source: This is available from outside means, such as published data, magazines, educational institutions etc.

(e) Make the forecast: Using the data collected in the selected method of forecasting, the forecast is made.

Forecasting Methods:

Methods or techniques of sales forecasting: Different authorities on marketing and production have devised several methods or techniques of sales or demand forecasting. The sales forecasts may be result of what market people or buyers say about the product or they may be the result of statistical and quantitative techniques. The most common methods of sales forecasting are:

1. ***Survey of buyer's inventions or the user's expectation method:*** Under this system of sales forecasting actual users of the product of the concern are contacted directly and they are asked about their intention to buy the company's products in an expected given future usually a year. Total sales forecasts of the product then estimated on the basis of advice and willingness of various customers. This is most direct method of sales forecasting.

The chief advantages of this method are:

(i) Sales forecast under this method is based on information received or collected from the actual users whose buying actions will really decide the future demand. So, the estimates are correct.

(ii) It provides a subjective feel of the market and of the thinking behind the buying intention of the actual uses. It may help the development of a new product in the market.

(iii) This method is more appropriate where users of the product are numbered and a new product is to be introduced for which no previous records can be made available.

(iv) It is most suitable for short-run forecasting.

2. ***Collective opinion or sales force composite method:*** Under this method, views of salesmen, branch manager, area manager and sales manager are secured for the different segments of the market. Salesmen, being close to actual users are required to estimate expected sales in their respective territories and sections. The estimates of individual salesmen are then consolidated to find out the total estimated sales for the coming session. These estimates are then further examined by the successive executive levels in the light of various factors like proposed changes in product design, advertising and selling prices, competition etc. before they are finally emerged for forecasting.

3. ***Group executive judgement or executive judgement method:*** This is a process of combining, averaging or evaluating, in some other way, the opinions and views of top executives. Opinions are sought from the executives of different fields i.e., marketing; finance; production etc. and forecasts are made.

4. ***Experts' opinions:*** Under this method, the organisation collects opinions from specialists in the field outside the organisation. Opinions of experts given in the newspapers and journals for the trade, wholesalers and distributors for company's products, agencies or professional experts are taken. By analysing these opinions and views of experts, deductions are made for the company's sales, and sales forecasts are done.

5. ***Market test method:*** Under this method seller sells his product in a part of the market for sometimes and makes the assessment of sales for the full market on the bases of results of test sales. This method is quite appropriate when the product is quite new in the market or good estimators are not available or where buyers do not prepare their purchase plan.

6. ***Trend projection method:*** Under this method, a trend of company's or industry's sales is fixed with the help of historical data relating to sales which are collected, observed or recorded at successive intervals of time. Such data is generally referred to as time series. The change in values of sales is found out. The study may show that the sales sometimes are increasing and sometimes decreasing, but a general trend in the long run will be either upward or downward. It cannot be both ways. This trend is called secular trend. The sales forecasts with the help of this method are made on the assumption that the same trend will continue in the future. The method which is generally used in fitting the trend is the method of least squares or straight line trend method. With this method a straight line trend is obtained. This line is called 'line of best fit'. By using the formula of regression equation of Y on X, the future sales are projected.

Calculation of trend.

The trend can be calculated by the least square method as follows:

(i) Find time deviations (X) of each period from a certain period and then find the sum of time deviation (ΣX).

(ii) Square the time deviation of each period (X^2) and then find the sum of squares of each period (ΣX^2).

(iii) Multiply time deviations with the sales of each period individually (XY) and add the product of the column to find (ΣXY).

(iv) To find the trend (Y) this is equal to a + bX. The value of a and b may be determined by either of the following two ways:

(a) Direct method. This method is applicable only when $\Sigma X=0$. To make $\Sigma X=0$, it is necessary that the time deviations should be calculated exactly from the mid point of the series. Then, the values of a and b will be calculated as follows:

$$\text{a (average)} = \frac{\sum Y}{n} \text{ and b (rate of growth)} = \frac{\sum XY}{\sum Y^2}$$

This method is simple and direct.

(b) Indirect method. This method is somewhat difficult. This method can be applied in both the cases where ΣX has any positive or negative values or ΣX is not equal to zero. The values of a and b are calculated by solving the following two equations:

$$\Sigma Y = na + b\Sigma X$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2$$

By calculating the values of a and b in the above manner, the sales can be forecasted for any future period by applying the formula Y = a + bX.

7. ***Moving average method:*** This is another statistical method to calculate the trend through moving averages. It can be calculated as follows:

An appropriate period is to be determined for which the moving average is calculated. While determining the period for moving averages, the normal cycle time of changes in the values of series should be considered so that short-term fluctuations are eliminated. As far as possible, the period for moving averages should be in odd numbers such as period of 3, 5 or 7 years. The period in even numbers will create a problem in centralising the values of averages. The calculated values of moving averages present the basis for determining the expected amount of sale.

8. ***Criteria of a good forecasting method:*** It cannot be said which method of sales forecasting is the best because everyone has merits and demerits of its own. The suitability of a method depends on various factors such as nature of theproduct, available time and past records, wealth and energy, degree of accuracy and the forecaster etc. of an enterprise. However, in general, a good forecasting method must possess the following qualifications.

   (i) ***Accuracy:*** Accuracy of the forecasting figures is the life blood of the business because many important plans and programmes, policies andstrategies are prepared and followed on the basis of such estimates. If sales forecasts are wrong, the businessman suffer a big loss. Hence, the method of forecasting to be applied must amount to maximum accuracy.

   (ii) ***Simplicity:*** The method for forecasting should be very simple. If the method is difficult or technical, then there is every possibility of mistake. Some information are collected from outside and that will remain unanswered or inaccurate replies will be received, if the method is difficult. Management must also be able to understand and have confidence in the method.

   (iii) ***Economy:*** The method to be used should be economical taking into account the importance of the accuracy of forecast. Costs must be weighed against the importance of the forecast to the operations of the business.

   (iv) ***Availability:*** The method should be such for which the relevant information may be available immediately with reasonable accuracy. Moreover, the technique must give quick results and useful information to the management.

   (v) ***Stability:*** The data of forecasting should be such wherein the future changes are expected to be minimum and are reliable for future planning for sometime.

   (vi) ***Utility:*** The forecasting technique must be easily understandable and suitable to the management.

Problems and Solutions

Problem: 1

An investigation into the demand for colour TV sets in 5 towns has resulted in the following data:

Population of the town (in lakhs)	X:	5	7	8	11	14
No of TV sets demanded (in thousands)	Y:	9	13	11	15	19

Fit a linear regression of Y on X and estimate the demand for CTV sets for two towns with a population of 10 lakhs and 20 lakhs.

Solution:

Computation of trend values

Population (in lakhs)	**Sales of CTV (in thousands)**	**Squares of the population**	**Product of population and sales of colour TV**
X	Y	X^2	XY
5	9	25	45
7	13	49	91
8	11	64	88
11	15	121	165
14	19	196	266
$\Sigma X = 45$	$\Sigma y = 67$	$\Sigma X^2 = 455$	$\Sigma XY = 655$

Regression equation of Y on X

$$Y = a + bX$$

To find the values of a and b, the following two equations are to be solved

$$\Sigma Y = na + b\Sigma X \quad \text{... (i)}$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \quad \text{... (ii)}$$

By putting the values we get

$$67 = 5a + 45b \quad \text{... (iii)}$$

$$655 = 45a + 455b \quad \text{... (iv)}$$

Multiplying equation (iii) by 9 and putting it as no. (v) we get,

$$603 = 45a + 405b \quad \text{... (v)}$$

By deducting equation (v) from equation (iv); we get 52 = 50b

$$b = \frac{52}{50} = 1.04$$

By putting the value of b in equation (iii), we get

$$67 = 5a + 45 \times 1.04$$

or, $67 = 5a + 46.80$

or, $67\text{-}46.80 = 5a$

or, $5a = 20.20$

or, $a = \dfrac{20.20}{5}$

or $a = 4.04$

Now by putting the values of a, b and X (10 lakhs) in regression equation of Y on X, we get,

$$Y = a + bX$$

or, $$Y = 4.04 + 1.04\ (10)$$

or, $$Y = 4.04 + 10.40 \text{ or } 14.44 \text{ thousand CTV sets.}$$

Similarly sales estimates for town having population of 20 lakhs, by putting the values of X, a and b in regression equation can be found as

$$Y = 4.04 + 1.04\ (20)$$

$$= 4.04 + 20.80 = 24.84 \text{ thousands CTV sets.}$$

Hence expected demand for CTV for two towns will be 14.44 thousand and 24.84 thousand CTV sets.

Problem: 2

The annual sales of truck tyres manufactured by a company are as follows—

Year	(X)	2002	2003	2004	2005	2006
Sales ('000 units)	(Y)	53	64	86	54	83

Fit a linear trend equation to the sales figures and estimate the sales for 2007.

Solution:

Computation of Trend Values

Years	**Time Deviation from 2004 X**	**Sales in ('000 units) Y**	**Squares of time dev. mX²**	**Product of time deviations and sales XY**
2002	–2	53	4	–106
2003	–1	64	1	–64
2004	0	86	0	0
2005	+1	54	1	+54
2006	+2	83	4	+166
n = 5	ΣX = 0	ΣY = 340	ΣX² = 10	ΣXY = + 50

Regression equation of Y on X—

Y = a + bX

For calculating the values of a and b

$$a = \frac{\sum Y}{n} = \frac{340}{5} \text{ or } 68$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{50}{10} = 5$$

Hence, regression equation comes to Y = 68 + 5X with the help of this equation, the trend value for 2007 can be calculated as follows—

$Y_{2007} = 68 + 5(5) = 68 + 25 = 93$

The estimated sales for 2007 will be 93,000 units.

Problem: 3.

From the following time series data of sale project the sales for the next three years.

Year		2001	2002	2003	2004	2005	2006	2007
Sales (`000 units)		80	90	92	83	94	99	92

Solution.

Computation of Trend Values

Years	**Time Deviation from 2004 X**	**Sales in (`000 units) Y**	**Squares of time dev. X^2**	**Product of time deviations and sales XY**
2001	–3	80	9	–240
2002	–2	90	4	–180
2003	–1	92	1	–92
2004	0	83	0	0
2005	+1	94	1	+94
2006	+2	99	4	+198
2007	+3	92	9	+276
n = 5	$\Sigma X = 0$	$\Sigma Y = 630$	$\Sigma X^2 = 28$	$\Sigma XY = +56$

Regression equation of Y on X

Y = a + bX

To find the values of a and b

$$a = \frac{\sum Y}{n} = \frac{630}{7} = 90$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{56}{28} = 2$$

Hence regression equation comes to Y = 90 + 2X. With the help of this equation we can project the trend values for the next three years, i.e. 2008, 2009 and 2010.

Y_{2008} = 90 + 2(4) = 90 + 8 = 98 (000) units.

Y_{2009} = 90 + 2(5) = 90 + 10 = 100 (000) units.

Y_{2010} = 90 + 2(6) = 90+ 12= 102 (000) units.

Problem: 4

Project the trend of sales for the next 5 years from the following data –

Year	2003	2004	2005	2006	2007
Sales ('000units)	120	140	120	150	170

Solution.

Calculation of trend values of sales

Years	**Sales (in lakh of Rs.) Y**	**Time deviation (from 2005) X**	**Squares of time deviation X^2**	**Product of time deviations and sales XY**
2003	120	–2	4	–240
2004	140	–1	1	–140
2005	120	0	0	0
2006	150	+1	1	150
2007	170	+2	4	340
n = 5	ΣY = 700	ΣX = 0	$\Sigma X^2 = 10$	ΣXY = 110

Regression equation of Y on X

Y = a + bX

To find values of a and b

$$a = \frac{\sum Y}{n} = \frac{700}{5} = 140$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{110}{10} = 11$$

Hence regression equation is a + bX or 140 + 11X. With the help of this equation we can project the trend for the next five years as follows:

Y_{2008} = 140 + 11 × 3 = 140 + 33 = 173 lakh rupees.

Y_{2009} = 140 + 11 × 4 = 140 + 44 = 184 lakh rupees.

Y_{2010} = 140 + 11 × 5 = 140 + 55 = 195 lakh rupees.

Y_{2011} = 140 + 11 × 6 = 140 + 66 = 206 lakh rupees.

Y_{2012} = 140 + 11 × 7= 140 + 77 = 217 lakh rupees.

Problem: 5

An investigation into the use of scooters in 5 towns has resulted in the following data:

Population in town

Population in town (in lakhs)	(X)	4	6	7	10	13
No. of scooters	(Y)	4,400	6,600	5,700	8,000	10,300

Fit a linear regression of Y on X and estimate the number of scooters to be found in a town with a population of 16 lakhs.

Solution:

Computation of trend value

Population (in lakhs) X	**No. of scooters demanded** Y	**Squares of population** X^2	**Product of population and No. of scooters demanded** XY
4	4,400	16	17,600
6	6,600	436	39,600
7	5,700	49	39,900
10	8,000	100	80,000
13	10,300	169	1,33,900
$\Sigma X = 40$	$\Sigma Y = 35{,}000$	$\Sigma X^2 = 370$	$\Sigma XY = 3{,}11{,}000$

Regression equation of Y on X

$Y = a + bX$

To find the values of a and b we will have to solve the following two equations

$$\Sigma Y = na + b\Sigma X \quad \text{... (i)}$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \quad \text{....(ii)}$$

By putting the values, we get

$$35{,}000 = 5a + 40b \quad \text{... (iii)}$$

$$3{,}11{,}000 = 40a + 370b \quad \text{... (iv)}$$

By multiplying equation no. (iii) by 8 putting as equation (v) we get,

$$2{,}80{,}000 = 40a + 320b \quad \text{... (v)}$$

By subtracting equation (v) from equation (iv), we get

$$31{,}000 = 50b$$

or, $50b = 31{,}000$

or, $b = \dfrac{31000}{50} = 620$

By substituting the value of b in equation no. (iii), we get

$$35{,}000 = 5a + 40b$$

or $35{,}000 = 5a + 40 \times 620$

or $35{,}000 = 5a + 24{,}800$

or $10{,}200 = 5a$

or $a = \dfrac{10200}{5} = 2040$

Now putting the value of a, b and X (16 lakhs) in regression equation of Y on X, we get $Y = a + bX$

or, $Y = 2040 + 620\,(16)$

or $Y = 2040 + 9920$

or $Y = 11{,}960$

Hence, the expected demand of scooters for a town with a population of 16 lakhs will be 11,960 scooters.

Problem 6.

An investigation into the demand for TV sets in 7 towns has resulted in the following data:

Population (m 000) X :	11	14	14	17	17	21	25
No. of TV sets demande Y :	15	27	27	30	34	38	46

Fit a linear regression of Y on X, and estimate the demand for TV sets for a town with a population of 30,000.

Solution

Population (in '000) X	**No. of TV sets demanded** Y	**Squares of population** X^2	**Product of population and No. TV sets demanded** XY
11	15	121	165
14	27	196	378
14	27	196	378
17	30	289	510
17	34	289	578
21	38	441	798
25	46	625	1150
$\Sigma X = 119$ $n = 7$	$\Sigma Y = 217$	$\Sigma X^2 = 2157$	$\Sigma XY = 3957$

Regression equation of Y on X:Y = a + bX

To find the value of a and b the equations are to be solved:

$$\Sigma Y = na + b\Sigma X \quad \text{... (i)}$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \quad \text{... (ii)}$$

By putting the values, we get

$$217 = 7a + 119b \quad \text{...(iii)}$$

$$3957 = 119a + 2157b \quad \text{...(iv)}$$

Multiplying equation no. (iii) by 17 and putting it as no. (v) we get

$$3689 = 119a + 2023b \quad \text{...(v)}$$

By deducting equation (v) from (iv)

we get $268 = 134b$

or $134b = 268$

or, $b = \frac{268}{134} = 2$

By substituting the value of b in equation no. (iii), we get

$$217 = 7a + 119 \times 2$$

or $7a + 238 = 217$

or $7a = 217 - 238 = -21$ or $a = -3$

Now, by putting the values of a, b and X (i.e.,) in regression equation of Y on X, we get

$Y = -3 + 2 \times 30 = -3 + 60 = 57$

Hence, the expected demand for TV sets for a town with a population of 30,000 will be 57 sets.

Problem 7:

An investigation into the demand for coolers in 5 towns has resulted in the following data:

Population of the town (in lakhs)	X :	5	7	8	11	14
No. of coolers demanded	Y :	45	65	55	75	95

Fit a linear regression of Y on X and estimate the demand for coolers for a town with a population of 25 lakhs.

Solution:

Computation of demand for coolers for a population of 20 lakhs

Towns	Population of town (in lakhs) X	No. of coolers demanded Y	Squares of population X^2	Production and no. of coolers demanded XY
A	5	45	25	225
B	7	65	49	455
C	8	55	64	440
D	11	75	121	825
E	14	95	196	1,330
n = 5	$\Sigma X = 45$	$\Sigma Y = 335$	$\Sigma X^2 = 455$	$\Sigma XY = 3,275$

Regression equation of Y on X.

$$Y = a + bX$$

To find the values of a and b the following two regression equations are to be solved :

$$\Sigma Y = na + b\Sigma X \quad .....(i)$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \quad .....(ii)$$

By putting the values, we get

$$335 = 5a + 45b \quad .... (iii)$$

$$3,275 = 45a + 455b \quad .... (iv)$$

By multiplying equation (iii) by 9, we get

$$3,015 = 45a + 405b \quad .... (v)$$

By subtracting equation (v) from (iv) we get

$$45a + 455b = 3,275$$

$$\underline{45a + 405b = 3,015}$$

$$50b = 260$$

or $b = 260/50 = 5.2$

By putting the value of b in equation (iii), we get

$$335 = 5a + 45 \times 5.2$$

or $5a = 335 - 234 = 101$

or $a = 101/5 = 20.2$

By putting the value of a, b and X (which is 20) in regression equation of Y on X, we get

$$Y = a + bX$$

$Y = 20.5 + 5.2\ (20)$

$Y = 20.2 + 104 = 124.2$ or 124

or say expected demand for room coolers for a town having a population of 20 lakhs will be 124 room coolers.

Problem: 8

An investigation into the demand for coolers in five towns has resulted in the following data:

Population of the town (in lakhs)	X :	4	6	7	10	13
No. of coolers demanded	Y :	40	60	50	70	90

Fit a linear regression of Y on X and estimate the demand for coolers for a town with a population of 20 lakhs.

Solution:

Computation of trend values of sales.

Towns	**Population (in lakhs) X**	**Demand for room coolers Y**	**Squares of population X^2**	**Product of Population & demand XY XY**	**Trend values (Y = a + bX) Y**
A	4	40	16	160	20.40 + (5.2 x 4) = 41.2
B	6	60	36	360	20.4 + (5.2 x 6) = 51.6
C	7	50	49	350	20.4 + (5.2 x 7) = 56.8
D	10	70	100	700	20.4 + (5.2 x 10) = 72.4
E	13	90	169	1,170	20.4 + (5.2 x 13) = 88.0
n = 5	$\Sigma X = 40$	$\Sigma Y = 310$	$\Sigma X^2 = 370$	$\Sigma XY = 2{,}740$	= 310

Regression equation of Y on X = Y = a + bX

To find out the value of a and b, the following two regression equations are to be solved:

$$\Sigma Y = na + b\Sigma X \qquad \text{... (i)}$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \qquad \text{... (ii)}$$

By putting the values in the above two equations

$$310 = 5a + 40b \qquad \text{...(iii)}$$

$$2{,}740 = 40a + 370b \qquad \text{... (iv)}$$

By multiplying the equation (iii) with 8 and deducting it from equation (iv)

$$2{,}480 = 40a + 320b \qquad \text{... (v)}$$

$$\underline{2{,}740} = \underline{40a + 370b} \qquad \text{... (vi)}$$

$$-260 = -\ 50b$$

or 50b = 260

or b = 260/50 = 5.2

By substituting the value of b in equation (iii)

310 = 5a + 40 × 5.2

or 5a = 310-208 = 102

or a = 102/5 = 20.4

Now by putting the values of a and b in regression equation of Y on X, we find the following equation:

Y = 20.4 + 5.2 (20) = 20.4 + 104 = 124.4 or say 124

Problem: 9

With the help of following data project the trend of sales for the next five years:

Years	2002	2003	2004	2005	2006	2007
Sales (in lakhs)	100	110	115	120	135	140

Solution:

Computation of trend values of sales

Year	**Time deviations from the middle of 2004 and 2005 assuring 5 years = 1**	**Sales (in lakh Rs.)**	**Squares of time deviation**	**Product of time deviation and sales**
	X	**Y**	**X^2**	**XY**
2002	-5	100	25	-500
2003	-3	110	9	-330
2004	-1	115	1	-115
2005	+1	120	1	+120
2006	+3	135	9	+405
2007	+ 5	140	25	+700
n = 6	$\Sigma X = 0$	$\Sigma Y = 720$	$\Sigma X^2 = 70$	$\Sigma XY = 280$

Regression equation of Y on X:

Y = a + bX

To find the values of a and b

$$a = \frac{\sum Y}{n} = \frac{720}{6} = 120$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{280}{70} = 4$$

Sales forecast for the next years, i.e., 2008 to 2012

Y_{2008}= 120 + 4 (+7) = 120 + 28 = Rs. 148 lakhs

Y_{2009} =120 + 4 (+9) = 120 + 36 = Rs. 156 lakhs

Y_{2010} = 120 + 4 (+11) = 120 + 44 = Rs. 164 lakhs.

Y_{2011} =120 + 4 (+13) = 120 + 52 = Rs. 172 lakhs.

Y_{2012} = 120 + 4 (+15) = 120 + 60 = Rs. 180 lakhs.

Problem: 10

There exists a relationship between expenditure on research and its annual profit. The details of the expenditure for the last six years is given below. Estimate the profit when the expenditure is 6 units

Year	Expenditure for research (x)	Annual Profit (y)
2001	2	20
2002	3	25
2003	5	34
2004	4	30
2005	11	40
2006	5	31
2007	6	?

(One unit corresponds to 1 Crore Rs.)

Solution:

Year	Expenditure for research (x)	Annual Profit	xy	x^2
2001	2	20	40	4
2002	3	25	75	9
2003	5	34	170	25
2004	4	30	120	16
2005	11	40	440	121
2006	5	31	155	25
Total	30	180	1000	200

$$\bar{x} = \frac{30}{6} = 5 \text{ and } \bar{y} = \frac{180}{6} = 30$$

The values a and b are computed as follows: for a linear regression equation

$$y = a + bX$$

$$b = \frac{\sum xy - n\bar{x}\,\bar{y}}{\sum x^2 - n\bar{x}^2}$$

$$b = \frac{1000 - 6 \times 5 \times 30}{200 - 6 \times 5 \times 5} = \frac{1000 - 900}{200 - 150} = 2$$

$$a = \bar{y} - b\bar{x} = 30 - 2 \times 5 = 20$$

Thus, the model is y = 20 + 2x.

The profit when the expenditure is 6 units is

y = 20 + 2 × 6 = 32 units of Rs.

2.3 Capacity Planning and Utilization

Capacity Planning:

The effective management of capacity is the most important responsibility of production and operations management. The objective of capacity management i.e., planning and control of capacity is to match the level of operations to the level of demand.

Capacity planning is concerned with finding answers to the basic questions regarding capacity such as:

(i) What kind of capacity is needed?

(ii) How much capacity is needed?

(iii) When this capacity is needed?

Capacity planning is to be carried out keeping in mind future growth and expansion plans, market trends, sales forecasting, etc. Capacity is the rate of productive capability of a facility. Capacity is usually expressed as volume of output per period of time.

Capacity planning is required for the following:

- Sufficient capacity is required to meet the customers demand in time,
- Capacity affects the cost efficiency of operations,
- Capacity affects the scheduling system,
- Capacity creation requires an investment,
- Capacity planning is the first step when an organisation decides to produce more or new products.

Capacity planning is mainly of two types:

(i) Long-term capacity plans which are concerned with investments in new facilities and equipments. These plans cover a time horizon of more than two years.

(ii) Short-term capacity plans which takes into account work-force size, overtime budgets, inventories etc.

Capacity refers to the maximum load an operating unit can handle. The operating unit might be a plant, a department, a machine, a store or a worker. Capacity of a plant is the maximum rate of output (goods or services) the plant can produce.

The production capacity of a facility or a firm is the maximum rate of production the facility or the firm is capable of producing. It is usually expressed as volume of output per period of time (i.e., hour, day, week, month, quarter etc.). Capacity indicates the ability of a firm to meet market demand - both current and future.

Effective Capacity can be determined by the following factors:

Facilities - design, location, layout and environment.

Product - Product design and product-mix.

Process - Quantity and quality capabilities.

Human factors - Job content, Job design, motivation, compensation, training and experience of labour, learning rates and absenteeism and labour turn over.

Operational factors - Scheduling, materials management, quality assurance, maintenance policies, and equipment break-downs.

External factors - Product standards, safety regulations, union attitudes, pollution control standards.

Measurement of capacity

Capacity of a plant is usually expressed as the rate of output, i.e., in terms of units produced per period of time (i.e., hour, shift, day, week, month etc.). But when firms are producing different types of products, it is difficult to use volume of output of each product to express the capacity of the firm. In such cases, capacity of the firm is expressed in terms of money value (production value) of the various products produced put together.

Capacity Planning Decisions

Capacity planning involves activities such as:

(i) Assessing the capacity of existing facilities.

(ii) Forecasting the long-range future capacity needs.

(iii) Identifying and analysing sources of capacity for future needs.

(iv) Evaluating the alternative sources of capacity based on financial, technological and economical considerations.

(v) Selecting a capacity alternative most suited to achieve strategic mission of the firm.

Capacity planning is necessary when an organisation decides to increase its production or introduce new products into the market or to increase the volume of production to gain the advantages of economies of scale. Once the existing capacity is evaluated and a need for new or expanded facilities is determined, decisions regarding the facility location and process technology selection are undertaken.

When the long-range capacity needs are estimated through long-range forecasts for products, a firm may find itself in one of the two following situations:

(i) A capacity shortage situation where present capacity is not enough to meet the forecast demand for the product.

(ii) An excess or surplus capacity situation where the present capacity exceeds the expected future demand.

Factors affecting determination of plant capacity

(i) Capital investment required,

(ii) Changes in product design, process design, market conditions and product life cycles,

(iii) Flexibility for capacity additions,

(iv) Level of automation desired,

(v) Market demand for the product,

(vi) Product obsolescence and technology obsolescence and

(vii) Type of technology selected.

Forms of capacity planning:

Based on time-horizon

(i) Long-term capacity planning and

(ii) Short-term capacity planning

Based on amount of resources employed

(i) Finite capacity planning and

(ii) Infinite capacity planning

Factors Affecting Capacity Planning: Two kinds of factors affecting capacity planning are:

(i) ***Controllable Factors:*** amount of labour employed, facilities installed, machines, tooling, shifts of work per day, days worked per week, overtime work, subcontracting, preventive maintenance and number of production set ups.

(ii) ***Less Controllable Factors:*** absenteeism, labour performance, machine break-downs, material shortages, scrap and rework, strike, lock-out, fire accidents etc.

Capacity Requirement Planning : Capacity requirement planning (CRP) is a technique which determines what equipment and labour/personnel capacities are required to meet the production objectives (i.e., volume of products) as per the master production schedule and material requirement planning (MRP-I).

Capacity Requirement Planning Strategies:

Two types of capacity planning strategies used are:

(i) "Level capacity" plan and

(ii) "Matching capacity with demand" plan.

Level capacity plan is based in "produce-to-stock and sell" approaches wherein the production systems are operated at uniform production levels and finished goods inventories rise and fall depending upon whether production level exceeds demand or vice versa from time period to time period (say every quarter or every month).

"Matching capacity with demand" Plan: In this plan, production capacity is matched with the demand in each period (weekly, monthly or quarterly demand). Usually, material flows and machine capacity are changed from quarter to quarter to match the demand. The main advantages are low levels of finished goods inventory resulting in lesser inventory carrying costs. Also, the back-ordering cost is also reduced. The disadvantages are high labour and material costs because of frequent changes in workforce (hiring, training and lay-off costs, overtime or idle time cost or subcontracting costs).

Optimum Plant Capacity: Plant capacity has a great influence on cost of production with increasing volume of production, economies of scale arises which results in reduction in average cost per unit produced.

For a given production facility, there is an optimum volume of output per year that results in the least average unit cost. This level of output is called the "best operating level" of the plant.

As the volume of output increases outward from zero in a particular production facility, average unit costs fall. These declining costs are because of the following reasons: (i) Fixed costs are spread over more units produced, (ii) Plant construction costs are less, (iii) Reduced costs of purchased material due to quantity discounts for higher volume of materials purchased and (iv) Cost advantages in mass production processes. Longer production runs (i.e., higher batch quantity of products produced) have lesser setup cost per unit of product produced, lesser scrap etc., resulting in savings which will reduce the cost of production per unit. This is referred to as "economies of scale". But this reduction in per unit cost will be only upto certain volume of production. Additional volumes of outputs beyond this volume results in ever-increasing average unit production cost. This increase in cost per unit arise from increased congestion of materials and workers, which decreases efficiency of production, and due to other factors such as difficulty in scheduling, damaged products, reduced employee morale due to excessive work pressure, increased use of overtime etc., resulting in "diseconomies of scale". Hence, the plant capacity should be such that the optimum level of production which gives the minimum average cost of production per unit should be possible. This plant capacity is referred to as optimum plant capacity.

Balancing the Capacity: In firms manufacturing many products (a product line or a product-mix) the load on different machines and equipments vary due to changes in product-mix. When the output rates of different machines do not match with the required output rate for the products to be produced, there will be an imbalance between the work loads of different machines. This will result in some machine or equipment becoming a "bottleneck work centre" thereby limiting the plant capacity which wills in-turn increase the production costs per unit.

To overcome problem of imbalance between different machines, additional machines or equipments are added to the bottleneck work-centre to increase the capacity of the bottle-neck work centre to match with the capacity of other work centres. Adding new machines or equipments to bottleneck work centres to remove the imbalance in capacity between various work centres is found to be economical than giving excessive overtime to workers working in bottle-neck centres which increases production costs. Another method to remove imbalance is to subcontract excess work load of bottleneck centres to outside vendors or subcontractors. Another way to balance capacities is to try to change the productmix by manipulating the sales for different products to arrive at a suitable product-mix which loads all work centres almost uniformly.

Implications of Plant Capacity

There are two major cost implications of plant capacity:

(i) Changes in output of an existing plant of certain installed capacity affect the production costs.

(ii) Changes in the plant capacity by changing the size of a plant have significant effects on costs.

Factors influencing Effective Capacity

The effective capacity is influenced by – (1) Forecasts of demand, (2) Plant and labour efficiency, (3) Subcontracting, (4) Multiple shift operation, (5) Management policies.

Forecasts of demand: Demand forecast is going to influence the capacity plan in a significant way. As such, it is very difficult to forecast the demand with accuracy as it changes significantly with the product life-cycle stage, number of products. Products with long lifecycle usually exhibit steady demand growth compared to one with shorter life-cycle. Thus the accuracy of forecast influences the capacity planning.

Plant and labour efficiency: It is difficult to attain 100 per cent efficiency of plant and equipment. The efficiency is less than 100 percent because of the enforced idle time due to machine breakdown, delays due to scheduling and other reasons. The plant efficiency varies from equipment to equipment and from organisation to organisation. Labour efficiency contributes to the overall capacity utilisation. The standard time set by industrial engineer is for a representative or normal worker. But the actual workers differ in their speed and efficiency. The actual efficiency of the labour should be considered for calculating efficiency. Thus plant and labour efficiency are very much essential to arrive at realistic capacity planning.

Subcontracting: Subcontracting refers to off loading, some of the jobs to outside vendors thus hiring the capacity to meet the requirements of the organisation. A careful analysis as to whether to make or to buy should be done. An economic comparison between cost to make the component or buy the component is to be made to take the decision.

Multiple shift operation: Multiple shifts are going to enhance the firm's capacity utilisation. But especially in the third shift the rejection rate is higher. Specially for process industries where investment is very high it is recommended to have a multiple shifts.

Management policy: The management policy with regards to subcontracting, multiplicity of shifts (decision regarding how many shifts to operate), which work stations or departments to be run for third shift, machine replacement policy, etc., are going to affect the capacity planning.

Factors favouring over capacity and under capacity

It is very difficult to forecast demand as always there is an uncertainty associated with the demand. The forecasted demand will be either higher or lower than the actual demand. So always there is a risk involved in creating capacity based on projected demand. This gives rise to either over capacity or under capacity.

The over capacity is preferred when:

(a) Fixed cost of the capacity is not very high.

(b) Subcontracting is not possible because of secrecy of design and/or quality requirement.

(c) The time required to add capacity is long.

(d) The company cannot afford to miss the delivery, and cannot afford to loose the customer.

(e) There is an economic capacity size below which it is not economical to operate the plant.

The under capacity is preferred when:

(a) The time to build capacity is short.

(b) Shortage of products does not affect the company (i.e., lost sales can be compensated).

(c) The technology changes fast, i.e., the rate of obsolescence of plant and equipment are high.

(d) The cost of creating the capacity is prohibitively high.

Aggregate Planning:

Aggregate planning is an intermediate term planning decision. It is the process of planning the quantity and timing of output over the intermediate time horizon (3 months to one year). Within this range, the physical facilities are assumed to be fixed for the planning period. Therefore, fluctuations in demand must be met by varying labour and inventory schedule. Aggregate planning seeks the best combination to minimise costs.

Production planning in the intermediate range of time is termed as 'Aggregate Planning'. It is thus called because the demand on facilities and available capacities is specified in aggregate quantities. For example aggregate quantities of number of Automobile vehicles, Aggregate number of soaps etc. Here the total expected demand is specified without regard to the product mix that makes up the specified figure.

While dealing with production problems, the planning process is normally divided in three categories.

(i) Long range Planning which deals with strategic decisions such as purchase of facilities, introduction of new products, processes etc.

(ii) Short term planning which deals with day-to-day work, scheduling and sometimes inventory problems.

(iii) Intermediate Planning or Aggregate Planning, which is in between long range and short term planning, which is concerned in generally acceptable planning taking the load on hand and the facilities available into considerations. In aggregate planning the management formulates a general strategy by which capacity can be made to satisfy demand in a most economical way during a specific moderate time period, say for one year. The aggregate planning is made operational through a master schedule that gives the manufacturing schedule (Products and dates of manufacture). Generally, day-to-day schedules are prepared from master schedule. Facility planning and scheduling has got very close relationship with aggregate planning.

Aggregate Planning Strategies:

The variables of the production system are labour, materials and capital. More labour effort is required to generate higher volume of output. Hence, the employment and use of overtime (OT) are the two relevant variables. Materials help to regulate output. The alternatives available to the company are inventories, back ordering or subcontracting of items.

These controllable variables constitute pure strategies by which fluctuations in demand and uncertainties in production activities can be accommodated.

Vary the size of the workforce: Output is controlled by hiring or laying off workers in proportion to changes in demand.

Vary the hours worked: Maintain the stable workforce, but permit idle time when there is a slack and permit overtime (OT) when demand is peak.

Vary inventory levels: Demand fluctuations can be met by large amount of inventory.

Subcontract: Upward shift in demand from low level. Constant production rates can be met by using subcontractors to provide extra capacity.

Aggregate planning guidelines:

1. Determine corporate policy regarding controllable variables.
2. Use a good forecast as a basis for planning.
3. Plan in proper units of capacity.
4. Maintain the stable workforce.
5. Maintain needed control over inventories.
6. Maintain flexibility to change.
7. Respond to demand in a controlled manner.
8. Evaluate planning on a regular basis.

Properties of Aggregate Planning: To facilitate the production manager the aggregate planning must have the following characteristics:

(i) Both out put and sales should be expressed in a logical overall unit of measuring. For example, an automobile manufacturing can say 1000 vehicles per year, without giving the number of each verity of vehicle. Similarly a paint industry can say 10,000 litres of paint and does not mention the quantities of each colour.

(ii) Acceptable forecast for some reasonable planning period, say one year.

(iii) A method of identification and fixing the relevant costs associated with the plant. Availability of alternatives for meeting the objective of the organization.

Ability to construct a model that will permit to take optimal or near optimal decisions for the sequence of planning periods in the planning horizon.

(iv) Facilities that are considered fixed to carry out the objective.

Problems and Solutions

Problem 1:

A department works on 8 hours shift, 250 days a year and has the usage data of a machine, as given below:

Product	Annual demand (units)	Processing time (standard time in hours)
X	300	4.0
Y	400	6.0
Z	500	3.0

Determine the number of machines required.

Solution:

Step 1: Calculate the processing time needed in hours to produce product x, y and z in the quantities demanded using the standard time data.

Product	Annual demand (units)	Standard processing per unit (Hrs.)	Processing needed (Hrs.)
X	300	4.0	300 x 4 = 1200 Hrs.
Y	400	6.0	400 x 6 = 2400 Hrs.
Z	500	3.0	500 x 3 = 1500 Hrs.
			Total = 5100 Hrs

Step 2 : Annual production capacity of one machine in standard hours

$= 8 \times 250 = 2000$ hours per year

Step 3 : Number of machines required

$$= \frac{\text{Work load per year}}{\text{Production capacity per machine}} = \frac{5100}{2000} = 2.55 \text{ machines} = 3 \text{ machines.}$$

Problem 2:

A steel plant has a design capacity of 50,000 tons of steel per day, effective capacity of 40,000 tons of steel per day and an actual output of 36,000 tons of steel per day. Compute the efficiency of the plant and its utilisation.

Solution:

Actual output

$$\text{Efficiency of the plant} = \frac{\text{Actual output}}{\text{Effective Capacity}} = \left(\frac{36000}{40000}\right) \times 100 = 90\%$$

$$\text{Utilisation} = \left(\frac{\text{Actual output}}{\text{Design Capacity}}\right) = \left(\frac{36000}{50000}\right) \times 100 = 72\%$$

Problem 3:

An item is produced in a plant having a fixed cost of Rs. 6,000 per month, variable cost of rupees 2 per unit and a selling price of Rs. 7 per unit. Determine

(a) The break-even volume.

(b) If 1000 units are produced and sold in a month, what would be the profit?

(c) How many units should be produced to earn a profit of Rs. 4000 per month?

Solution:

(a) Break-even-volume

Fixed cost (FC) = Rs. 6000 per month

Variable cost (VC) = Rs. 2 per unit

Selling price (SP) = Rs. 7 per unit

Let Q be the break even volume per month, then

Total cost = Fixed Cost + (Variable cost / unit) × Quantity

TC = FC + (VC ×Q) = 6000 + 2Q

Sales Revenue = Selling price per unit × Quantity = 7Q

For Q to be break-even volume,

Sales Revenue = Total cost

i.e., 7Q = 6000 + 2Q

5Q = 6000

$$Q = \left(\frac{6000}{5}\right) = 1200 \text{ units / month}$$

(b) For Q = 1000,

Profit = Sales Revenue - Total cost

= SR - (FC + VC × Q)

= (7 × 1000) - (6000 + 2 × 1000)

= (7000) - (6000 + 2000)

= Rs. 7000 - 8000 = -Rs 1000 (i.e., loss of Rs. 1000)

(c) For profit of Rs. 4000, What is Q?

SR = FC + (VC) Q + Profit

7Q = 6000 + 2Q + Profit

7Q - 2Q = Rs (6000 + 4000)

5Q = Rs. 10,000

$$Q = \left(\frac{10000}{5}\right) = 2000 \text{ units}$$

Problem 4:

A manager has to decide about the number of machines to be purchased. He has three options i.e., purchasing one, or two or three machines. The data are given below.

Number of machine	Annual fixed cost	Corresponding range of output
One	Rs. 12,000	0 to 300
Two	Rs. 15,000	301 to 600
Three	Rs. 21,000	601 to 900

Variable cost is Rs. 20 per unit and revenue is Rs. 50 per unit

(a) Determine the break-even point for each range

(b) If projected demand is between 600 and 650 units how many machines should the manager purchase?

Solution:

(i) Break-even point

Let QBEP be the break even point.

FC = Fixed cost, R = Revenue per unit, VC = Variable cost

Then QBEPR = FC + (VC) QBEP

$$QBEP = \frac{FC}{(R - VC)}$$

Let Q1 be the break-even-point for one machine option

$$\text{Then, } Q1 = \frac{12000}{(50-20)} = \frac{12000}{30} = 400 \text{ units}$$

(Not within the range of 0 to 300)

Let Q2 be the break-even-point for two machines option.

$$\text{Then, } Q2 = \frac{15000}{(50-20)} = \frac{15000}{30} = 500 \text{ units}$$

(within the range of 301 to 600)

Let Q3 be the break-even-point for three machines option.

$$\text{Then, } Q3 = \frac{21000}{(50-20)} = \frac{21000}{30} = 700 \text{ units}$$

(with in the range of 601 to 900)

(ii) The projected demand is between 600 to 650 units.

The break even point for single machine option (i.e., 400 units) is not feasible because it exceeds the range of volume that can be produced with one machine (i.e., 0 to 300).

Also, the break even point for 3 machines is 700 units which is more than the upper limit of projected demand of 600 to 650 units and hence not feasible. For 2 machines option the break even volume is 500 units and volume range is 301 to 600.

Hence, the demand of 600 can be met with 2 machines and profit is earned because the production volume of 600 is more than the break even volume of 500. If the manager wants to produce 650 units with 3 machines, there will be loss because the break even volume with three machines is 700 units. Hence, the manager would choose two machines and produce 600 units.

Problem 5:

A firm has four work centres, A, B, C & D, in series with individual capacities in units per day shown in the figure below.

Work centres

Raw materials → **A** (450) → **B** (360) → **C** (340) → **D** (400) → Actual Output (300)

(i) Identify the bottle neck centre.

(ii) What is the system capacity?

(iii) What is the system efficiency?

Solution:

(i) The bottle neck centre is the work centre having the minimum capacity. Hence, work centre 'C' is the bottleneck centre.

(ii) System capacity is the maximum units that are possible to produce in the system as a whole. Hence, system capacity is the capacity of the bottle neck centre i.e., 340 units.

(iii) System efficiency = $\dfrac{\text{Actual output}}{\text{System capacity}}$

$= \dfrac{300}{340}$ x 100 (i.e., maximum possible output) = 88.23%

Problem 6.

A firm operates 6 days a week on single shift of 8 hours per day basis. There are 10 machines of the same capacity in the firm. If the machines are utilised for 75 percent of the time at a system efficiency of 80 percent, what is the rated output in terms of standard hours per week?

Solution

Maximum number of hours of work possible per week

= (Number of machines) × (Machine hours worked per week)

= 10 ×6 × 8 = 480 hours

If the utilisation is 75% then number of hours worked = 480 × 0.75 = 360 hours.

Rated output = utilised hours × system efficiency = 360 × 0.8 = 288 standard hours.

Problem: 7

The order position (i.e., requirements of despatch) for the next twelve months in respect of a particular product is as under:

Month	Required units	Month	Required units
1	13,000	7	11,000
2	12,000	8	7,000
3	10,000	9	15,000
4	9,000	10	13,000
5	11,000	11	12,000
6	13,000	12	10,000

The production capacity or the shop is 10,000 units per month on regular basis and 3,000 units per month on overtime basis. Sub-contracting can be relied upon up to a capacity of 3,000 units per month after giving a lead time of 3 months. Cost data reveal as under: Rs. 5.00 per piece on regular basis Rs. 9.00 per piece on overtime basis Rs. 7.00 per piece on sub-contract basis Cost of carrying Inventory is Re. 1.00 per unit per month. Assuming an initial inventory of 1,000 units and that no backlogging of orders is permissible, suggest an optimal production schedule. Also work out the total cost on the basis of the suggested schedule.

Solution:

The optimum production schedule is as follows:

Month	Required No. of Units ('000)	No. of Units Production (6000)		Sub-contract ('000 units)		Inventory the end of month ('000) units
		Regular Time	Over Time	Order placed for	Delivered	
1	13	10	2	—	—	0
2	12	10	2	—	—	0
3	10	10	0	3	—	0
4	9	10	0	1	—	1
5	11	10	0	—	—	0
6	13	10	0	2	3	0
7	11	10	0	3	1	0
8	7	10	0	+2	—	3
9	15	10	0	—	2	0
10	13	10	0	—	3	0
11	12	10	0	—	2	0
12	10	10	0	—	—	0

Cost of production on regular basis = Rs. 1,20,000 × 5 = Rs. 6,00,000;

Cost of production on overtime = Rs. 4,000 × 9 = Rs. 36,000; Cost of sub-contracting

= Rs. 11,000 × 7 = Rs. 77,000

Cost of carrying inventory = Rs. 4,000 × 1 = Rs. 4,000; Total cost on the basis of the suggested schedule= (Rs.6,00,000 + Rs. 36,000 + Rs. 77,000 + Rs. 4,000) = Rs. 7,17,000

Problem: 8

A manufacturing company has a product line consisting of five work stations in series. The individual workstation capacities are given. The actual output of the line is 500 units per shift.

Calculate (i) System capacity (ii) Efficiency of the production line

Workstation No.	A	B	C	D	E
Capacity/Shift	600	650	650	550	600

Solution:

(i) The capacity of the system is decided by the workstation with minimum capacity/shift, i.e., the bottleneck. In the given example, the work station 'D' is having a capacity of 550 units/ shift which is a minimum.

Therefore, the system capacity = 550 units/shift. (ii) The actual output of the line = 500 units/shift.

Therefore, the system efficiency = $\frac{\text{Actual capacity}}{\text{System capacity}}$ x 100 = $\frac{500}{550}$ x 100 = 90.91 %

Problem: 9

A company intends to buy a machine having a capacity to produce 1,70,000 good parts per annum. The machine constitutes a part of the total product line. The system efficiency of the product line is 85%.

(i) Find the system capacity.

(ii) If the time required to produce each part is 100 seconds and the machine works for 2000 hours per year. If the utilisation of the machine is 60% and the efficiency of the machine is 90%, compute the output of the machine.

(iii) Calculate the number of machines required?

Solution:

(i) System capacity $= \frac{\text{Actual output / annum}}{\text{System efficiency}} = \frac{1,70,000}{0.85}$ = 2,00,000 units / annum

$= \frac{2,00,000}{2,000}$ = 100 units/hours

(ii) Output per annum = Unit capacity × % utilisation × efficiency

$$\text{Unit capacity} = \frac{60 \times 60 \text{ sec}}{100 \text{ sec per unit}} = 36 \text{ units}$$

Output per hour = 36 × 0.6 × 0.9 = 19.44 units = 20 units.

(iii) $\text{Number of machines required} = \frac{\text{System capacity}}{\text{Output per hour}} = \frac{100}{20} = 5 \text{ machines}$

Problem: 10

The following activities constitute a work cycle.

(i) Find the total time, theoretical output obtained from the machine.

(ii) Calculate the number of machines required to produce the three components from the information given below.

Sr. No.	Activity	Time (min)
1.	Unloading	0.25
2.	Inspection	0.35
3.	Loading job on machine table	0.40
4.	Machine operation time	0.90

Components	A	B	C
1. Setup time per batch	25 min	55 min	45 min
2. Operation time (min/piece)	1.75	3.0	2.1
3. Batch size	350	550	575
4. Production per month	2450	4400	2875

Solution:

(i) Total cycle time (T) = 0.25 + 0.35 + 0.40 + 0.90 = 1.90 min.

(ii) Output of the machine

$$\text{Output} = \frac{60}{1.9} = 31.5 \approx 31 \text{ units.}$$

(iii) Number of machines required

Assume that the plant works on the single shift basis per day of 8 hours each.

The total time required for the processing the components is given by

Total time required = Setup time + operation time.

For component A,

Total time required = Setup time + operation time

$$= \left[\left(\frac{\text{Production quantity}}{\text{Batch size}}\right) \times \left(\frac{\text{Setup time}}{\text{Batch}}\right)\right] + \text{Operation time}$$

$$= \left(\frac{2450}{350} \times \frac{25}{60}\right) + \left(2450 \times \frac{1.75}{60}\right) = 2.916+71.458=74.374 \text{ hrs.}$$

For component B,

$$\text{Total time required} = \left(\frac{4400}{550} \times \frac{55}{60}\right) + \left(4400 \times \frac{3}{60}\right) = 22/3+220=227.33 \text{ hrs.}$$

For component C,

$$\text{Total time required} = \left(\frac{2875}{575} \times \frac{45}{60}\right) + \left(2875 \times \frac{2.1}{60}\right) = 3.75+100.625=104.375\text{hrs.}$$

Total time (hrs) required to process all the three components

= 74.374 + 227.33 + 104.375 = 406.079 hrs. Total number of hours available (assuming 25 working days) per month = 8 × 25 = 200 hrs.

$$\text{Number of machines required} = \frac{\text{Total number of machine hours required}}{\text{Total number of hours available}} = \frac{406.079}{200}$$

$$= 2.030 \approx 2 \text{ machines.}$$

Assuming a machine efficiency of 85% and operator efficiency of 75%, the number of machines required are:

$$\text{Total hours required per month} = \frac{406.079}{0.85 \times 0.75} = 636.98 \text{ hrs.}$$

$$\text{Number of machines required} = \frac{636.98}{200} = 3.18 \approx 4 \text{ machines.}$$

Problem: 11

Three components are to be manufactured on three machines i.e. Center lathe, Milling machine and Cylindrical grinding machine.

(i) Calculate the number of machines required of each kind to produce the components if the plant works for 48 hours per week.

(ii) Calculate the number of machines required assuming the machine efficiency of 75%.

(iii) How do you reduce the number of machines. The following information is given:

Machine	Component A Setup operation		Component B Setup operation		Component C setup operation	
1 Center lathe	30 min	2min	55min	2.5 min	40 min	1.5 min
2 Milling machine	45 min	8 min	30 min	4 min	–	–
3 Cylindrical grinding	50 min	8 min	60 min	8 min	60 min	10 min
Other details						
Lot size	350		400		600	
Quantity demanded / month	1750		4000		3000	

Solution:

The total time required to process the required components on the machines

(i) Center Lathe

(a) Total time required for Component A= $\left(\dfrac{1750}{350}\times\dfrac{30}{60}\right)+\left(1750\times\dfrac{2}{60}\right)$ = 60.83 hours

(b) Total time required for Component B = $\left(\dfrac{4000}{400}\times\dfrac{55}{60}\right)+\left(4000\times\dfrac{2.5}{60}\right)$ = 175.832 hours

(c) Total time required for Component C = $\left(\dfrac{3000}{600}\times\dfrac{40}{60}\right)+\left(4000\times\dfrac{1.5}{60}\right)$ = 78.33 hours

Total time required to process the components on center lathe

= a +b+ c = 60.83 + 175.83 + 78.333 = 314.993 hrs/month.

Available time per machine per month = 48 × 4 = 192 hours.

Total hours required / month

No. of Lathe machines required = $\dfrac{\text{Total hours required/ month}}{\text{Total hours available/ month}} = \dfrac{314.993}{192}$ = 1.64 $\approx$ 2 nos.

If the machine efficiency is considered as 85%, then

No. of lathes required = $\dfrac{\text{Total hours required/ month}}{\text{Total No. of hours available / month}\times\text{machine efficiency}}$

$= \dfrac{314.993}{192\times 0.75}$ = 2.18 $\approx$ 3 machines

(ii) Milling Machine

Total time required to process all the components per month

$$\left(\frac{1750}{350}\times\frac{45}{60}+1750\times\frac{8}{60}\right)+\left(\frac{4000}{400}\times\frac{30}{60}+4000\times\frac{4}{60}\right) = 508.749 \text{ hours.}$$

Number of milling machines required

$$= \frac{\text{Total hours required/ month}}{\text{Total hours available/ month}} = \frac{508.749}{192} = 3.53 \approx 4 \text{ nos.}$$

Cylindrical Grinding Machines

Total time required to process all the components per month

$$= \left(\frac{1750}{350}\times\frac{50}{60}+1750\times\frac{10}{60}\right)+\left(\frac{4000}{400}\times\frac{60}{60}+4000\times\frac{8}{60}\right)+\left(\frac{3000}{600}\times\frac{60}{60}+3000\times\frac{10}{60}\right)$$

= [4.166 + 291.666] + [10+533.333] + [5+500] = 1344.165 hours

$$\text{Number of milling machines required} = \frac{\text{Total hours required/ month}}{\text{Total hours available/ month}} = \frac{1344.165}{192}$$

$$= 7 \text{ machines}$$

If the machine efficiency is considered as 75%,

$$\text{Number of milling machine required} = \frac{1344.165}{192\times0.75} = 9.33 \approx 10 \text{ machines}$$

(iii) Reduction in number of machines

(a) By introducing the second and third shift, the number of hours available will be increased and hence the number of machines required will be reduced.

(b) By increasing the utilisation of the machine. The availability of the machine will be increased by proper maintenance which reduces the break down and hence the down time. The production time will be increased and hence the plant utilisation.

Problem: 12

Machines A and B are both capable of processing the product. The following informations is given

Particular	Machine A	Machine B
Investment	Rs. 75,000	Rs. 80,000
Interest on Capital invested	10%	15%
Hourly charge (wage + power)	Rs. 10	Rs. 8
Pieces produced per hour	5	8
Annual operating hours	2000	2000

Which machine will give the lower cost per unit of production, if run for the whole year? If only 4000 pieces are to be produced in a year, which machine would give the lower cost per piece.

Solution:

Computation of cost per unit of production of machines

Particulars	Machine A	Machine B
Interest (fixed cost)	Rs. 7,500	Rs. 12,000
Variable cost (hourly charge x annual operating hours)	Rs. 20,000	Rs. 16,000
Total cost	Rs. 27,500	Rs. 28,000
Total Output	5 x 2000 = 10,000	8 x 2000 = 16,000
Unit cost	Rs. 2.75	Rs. 1.75

If the output is 4000 units per annum

Particulars	Machine A	Machine B
Interest (fixed cost)	Rs. 7,500	Rs. 7,500
Variable cost (10 x 800)	Rs. 8,000	Rs. 4,000 (8 x 500)
Total cost	Rs. 15,500	Rs. 16,000
Unit cost	Rs. 3.89	Rs. 4.00

Note: 800 hours will be required to produce the commodity with machine A and 500 hrs on machine B.

Problem : 13

ABC. Co. has developed a forecast for the group of items that has the following demand pattern

Quarter	Demand	Cumulative demand
1	270	270
2	220	490
3	470	960
4	670	1630
5	450	2080
6	270	2350
7	200	2550
8	370	3920

The firm estimates that it costs Rs. 150 per unit to increase production rate Rs. 200 per unit to decrease the production rate, Rs. 50 per unit per quarter to carry the items in inventory and Rs. 100 per unit if subcontracted. Compare the costs of the pure strategies.

Solution:

Different pure strategies are

Plan I In this pure strategy, the actual demand is met by varying the work force size. This means that during the period of low demand, the company must fire the workers and during the period of high demand the company must hire workers. These two steps involve associated costs. In this strategy, the production units will be equal to the demand and values in each period. The cost of the plan is computed in the table below,

Quarter	Demand	Cost of increasing Production level (Rs)	Cost of decreasing Production level (Rs)	Total cost of plan (Rs.)
1	270	—	—	—
2	220	—	50 x 200 = 10,000	10,000
3	470	250 x 150 = 37,500	—	37,500
4	670	200 x 150 = 30,000	—	30,000
5	450	—	220 x 200 = 44,000	44,000
6	270	—	180 x 200 = 36,000	36,000
7	200	—	70 x 200 = 14,000	14,000
8	370	170 x 150 = 25,500	—	25,500
	Total			1,97,000

Plan II In this plan, the company computes the average demand and sets its production capacity to this average demand. This results in excess of units in some periods and also shortage of units during some other periods. The excess units will be carried as inventory for future use and shortage of units can be fulfilled using future inventory. The cost of the plan II is computer in the table. The plan incurs a maximum shortage of 255 units during 5 periods. The firm might decide to carry 255 units from the beginning of period 1 to avoid shortage. The total cost of the plan is Rs. 96,000.

Quar-ter	Demand forecast	Cumu lative demand	Production level	Cumu. prod. level	Inventory	Adjusted inventory with 255 at beginning of period 1	Cost of holding inventory Rs
1	270	270	365	365	95	350	17,500
2	220	490	365	730	240	495	24,750
3	470	960	365	1095	135	390	19,500
4	670	1630	365	1460	–170	85	4,250
5	450	2080	365	1825	–255	0	0
6	270	2350	365	2190	–160	95	4,750
7	200	2550	365	2555	5	260	13,000
8	370	3920	365	2920	0	255	12,750
	Total						96,500

Plan III

The additional demand other than the normal capacity is met by subcontracting. The cost of the plan III amounts to Rs. 1,32,000 as shown in table below.

Quarter	Demand forecast	Production units	Subcontract units	Incremental cost @ Rs. 100/units
1	270	200	70	70 x 100 = 7,000
2	220	200	20	20 x 100 = 2,000
3	470	200	270	270 x 100 = 27,000
4	670	200	470	470 x 100 = 47,000
5	450	200	250	250 x 100 = 25,000
6	270	200	70	70 x 100 = 7,000
7	200	200	0	0
8	370	200	170	170 x 100 = 17,000
			Total	= 1,32,000

The total cost of pure strategies is given below. On observation Plan II (Changing inventory levels) has the least cost.

Plan	Total cost (Rs)
Plan I	1,97,000
Plan II	96,500
Plan III	1,32,000

Problem: 14

A company manufactures the consumer durable products and the company intends to develop an aggregate plan for six months starting from January through June. The following information is available.

Demand and working days.

Month	Jan	Feb	Mar	Apr	May	June
Demand	500	600	650	800	900	800
Working day	22	19	21	21	22	20

Cost details

Materials	Rs. 100/ unit
Inventory carrying cost	Rs. 10/unit/month
Cost of stockout	Rs. 20/unit/month
Cost subcontracting	Rs. 200/unit
Hiring and training cost	Rs. 50/worker
Lay off cost	Rs. 100/worker
Labour hours required	Rs. 4/unit
Regular time cost (forfirst 8 hrs)	Rs. 12.50/hours
Overtime cost	Rs. 18.75/hr
Beginning inventory	200 units
Safety stock required	Nil

Work out the cost of the following strategies

1. Produce exactly to meet demand — vary the work force.
2. Constant work force — vary inventory and allow shortages
3. Constant work force and use subcontracting.

Solution:

Strategy I: Produce exactly to meet demand by varying work force.

Assumption: Opening workforce equals the first month's requirements.

Table: Aggregate production planning requirements

	Jan	Feb	Mar	Apr	May	June	Total
Beginning Inventory	200	0	0	0	0	0	
Forcasted demand	500	600	650	800	900	800	
Production requirement (demand + safety stock – beginning inventory	300	600	650	800	900	800	
Ending inventory (beginning inventory+ Production requirement – Demand forecast)	0	0	0	0	0	0	

Plan I — Exact Production, vary Work Force

	Jan	Feb	Mar	Apr	May	June	Total
Production requirement	300	460	650	800	900	800	
Production hours required (production requirement × 4 hr/unit)	1200	2400	2600	3200	3600	3200	
Working days per month	22	19	21	21	22	20	
Hours per month per worker (working days × 8 hrs/day)	176	152	168	168	176	160	
No. of workers' required (production hrs required + hrs per month per worker	7	16	15	19	20	20	
New worker hired (assuming opening work force equal to first months requirement of 7 workers)	0	9	0	4	1	0	
Hiring cost (workers hired × Rs. 50)	0	450	0	200	50	0	700
Workers laid off	0	0	1	0	0	0	
Lay off cost (workers laid off × 100)	0	0	100	0	0	0	100
Regular production cost (production hrs required × 12.50 Rs./hrs)	15,000	30,000	32,500	40,000	45,000	40,000	2,02,500
Total							2,03,300

Plan II — Constant Work Force, vary Inventory and Stockout

* Assume a constant work force of 10.

	Jan	Feb	Mar	Apr	May	June	Total
Beginning inventory	200	140	– 80	– 310	– 690	–1150	
Working days per month	22	19	21	21	22	20	
Production hrs available (working days/month×8 hrs/day × 10 workers)	1760	1520	1680	1680	1760	1600	
Actual production (production hrs available ÷ 4 hours/unit)	440	380	420	420	440	400	

	Jan	Feb	Mar	Apr	May	June	Total
Forecasted demand	500	600	650	800	900	800	
Ending inventory (beginning inventory + actual)	140	– 80	– 310	– 690	–1150	–1550	
Shortage cost (unit short × Rs.20/unit)	0	1600	6200	13800	23000	31000	75600
Units excess (ending inventory – safety stock)	140	0	0	0	0	0	
Inventory cost (unit excess × 10)	1400	0	0	0	0	0	1400
Regular production cost (production hrs required × 12.50 Rs./ hrs)	22000	19000	21000	21000	22000	20000	125000
Total							202000

Plan III — Constant Work Force Subcontract

	Jan	Feb	Mar	Apr	May	June	Total
Production requirement	300	460	650	800	900	800	
Working days per month	22	19	21	21	22	20	
Production hrs available (working days × 8 hrs/day × 10 workers)	1760	1520	680	1680	1760	1600	
Actual production (production hrs available ÷ 4 hours per unit)	440	380	420	420	440	400	
Unit subcontracted (production requirements – actual production)	0	220	230	380	460	400	
Subcontracting cost (units subcontracted ×Rs.100)	0	8000	23000	38000	46000	40000	155000
Regular production cost (production hrs required × 12.50 Rs./hrs)	22000	19000	21000	21000	22000	20000	125000
Total							280000

Note: Assume a constant work force of 10.

600 - 140 = 460 units of beginning inventory in February.

Summary of the Plans

Plan	Hiring	Lay off	Subcon–tract	RT. prod	Short–age	excess inven.	Total cost
Plan I – Exact production vary work force	700	100	–	2,02,500	–	–	2,03,300
Plan II – Constant work force vary inventory	–	–	–	1,25,000	75,600	1,400	2,02,000
and shortages Plan III – Constant work	–	–	155000	1,25,000	–	–	2,80,000

Problem: 15

A company is considering the expansion of a manufacturing process by adding more 1-Ton capacity furnaces. Each batch (1 ton) must undergo 30 minutes of furnace time, including load and unload operations. However the furnace is used only 80% of the time due to power restriction in other parts of the system. The required output for the new layout is to be 16 tons/shift (8 hours). Plant (system) efficiency is estimated at 50% of system capacity.

(a) Determine system capacity and the number of furnaces required

(b) Estimate the percentage of time, the furnaces will be idle.

Solution:

(a) Required system capacity

$$= \frac{16 \text{ tons/shift}}{0.5} = 32 \text{ tons / shift} = \frac{32}{8 \times 0.8} = 5 \text{ tons / hour}$$

$$\text{Individual furnace capacity} = \frac{1 \text{ ton}}{0.50 \text{ hour}} = 2 \text{ ton/hour per furnace}$$

$$\text{Number of furnaces required} = \frac{5 \text{ tons/hour}}{2 \text{ ton / hour per furnace}} = 2.5 \text{ (say)} \approx 3 \text{ furnaces.}$$

(b) Percentage of idle time:

Total hours available / shift = 3 furnaces × 8 hours = 24 furnace-hour

Total hours of actual use/shift = (24 -8) = 16 ton × 0.5 hour/ton = 8 furnace-hour

Idle time = 16 furnace-hour % of idle time = 16/24 = 67%

Problem: 16

Annual demand for a manufacturing company is expected to be as follows

Units demanded	8,000	10,000	15,000	20,000
Probability	0.50	0.20	0.20	0.10

Selling price is Rs. 35 per unit. The existing manufacturing facility has annual fixed operating cost of Rs. 2,06,000. Variable manufacturing costs are Rs. 7.75 per unit at the 8000 unit output level, Rs. 5 at the 10,000 unit level, Rs. 5.33 at the 15000 unit level and Rs: 7.42 at the 20,000 unit output level.

An expanded facility under consideration would require Rs. 2,50,000 fixed operating costs annually. Variable costs would average Rs. 9.40 at the 8000 unit level, Rs. 5.20 at 10,000 unit level, Rs. 3.80 at the 15000 unit level, and Rs. 4.90 at the 20000 level.

To maximise net earnings, which size facility should be selected?

Solution:

Expected net revenue of existing facility:

Expected variable cost

= [7.75×8000×0.5 + 5×10000×0.2 + 5.33×15000×0.2+ 7.42×20000×0.1]

= 31000+10000+15990+14840=Rs.71.830

Expected total cost = fixed cost + variable cost = 2,00,000 + 71,830 = Rs. 2,71,830

Expected sales = 35 [8000×0.5+10000×0.2 + 15000×0.2 + 20000×0.1]= Rs.3,85,000

Expected net revenue = 3,85,000-2,71,830 = Rs. 1,13,170

Expected net revenue of expanded facility: Expected variable cost

= [9.40×8000×0.5 + 5.20×10,000×0.2 + 3.80×15000×0.2 + 4.90×2000×0.1]

= 37600+10400+11400+980=Rs. 60,380

Expected total cost = fixed cost + variable cost = 2,50,000 + 60,380 = Rs.3,10,380 Expected net revenue = 3,85,000-3,10,380 = Rs. 74,620. Therefore, the existing facility maximises expected net earnings.

Problem: 17

A manufacturer has the following information on its major product

Regular - time production capacity = 2600 units/period.

Over time production costs = Rs. 12 per unit.

Inventory costs = Rs. 2 per unit per period (based on closing inventory)

Backlog costs = Rs. 5 per unit per period.

Opening inventory 400 units.

Demand (in units) for periods 1, 2, 3, 4, is 4000, 3200, 2000 and 2800 respectively. Develop a level output plan that yields zero inventory at the end of period 4. What costs result from this plan?

Solution:

Period	Demand (units)	Output (units)	Closing Inventory (units)	Regular output (units)	Overtime output
			400		
1	4000	2900	–700	2600	300
2	3200	2900	–1000	2600	300
3	2000	2900	–100	2600	300
4	2800	2900	0	2600	300
Average	3000		Total(–)1800		

Total Cost = Overtime + inventory + backlogs = (300×4×12) + (0×2) + (1800 ×5) = Rs.23,400.

Problem: 18

M Ltd. produces a product which has a 6-month demand cycle, as shown. Each unit requires 10 worker hours to be produced, at a labour cost of Rs. 6 per hour regular rate (or Rs. 9 per hour overtime). The total cost per unit is estimated at Rs. 200, but units can be subcontracted at a cost of Rs. 208 per unit. There are currently 20 workers employed in the subject department and hiring and training costs for additional workers are Rs. 300 per person, whereas layoff costs are Rs. 400 per person. Company policy is to retain a safety stock equal to 20% of the monthly forecast, and each month' s safety stock becomes the opening inventory for the next month. There are currently 50 units in stock carried at a cost of Rs. 2 per unit-month. Stockouts have been assigned a cost of Rs. 20 per unit-month.

	January	February	March	April	May	June
Forecast demand	300	500	400	100	200	300
Work days	22	19	21	21	22	20
Work hour at 8 per day	176	152	168	168	176	160

Three aggregate plans are proposed.

Plan I. Vary the work-force size to accommodate demand.

Plan II. Maintain a constant work-force of 20, and use overtime and idle times to meet demand.

Plan III. Maintain a constant workforce of 20 and build inventory or incur a stock out cost. The firm must begin January with the 50-unit inventory on hand.

Compare the costs of the three plans.

Solution:

We must first determine what the production requirements are as adjusted to include a safety stock of 20 per cent of next months forecast. Beginning with a January inventory of 50, each subsequent month's inventory reflects the difference between the forecast demand and the production requirement of the previous month.

	January	February	March	April	May	June
Forecast demand	300	500	400	100	200	300
Work days	22	19	21	21	22	20
Work hour at 8 per day	176	152	168	168	176	160

Plan I (Vary workforce size)

	Jan	Feb	Mar	Apr	May	June	Total (in Rs.)
Production Required	310	540	380	40	220	320	
Production hrs. Required	3100	5400	3800	400	2200	3200	
Available Hrs./worker	176	152	168	168	176	160	
No. of worker Required	18	36	23	3	13	20	
No. of worker Hired	–	18	–	–	10	7	
Hiring Cost		5400		–	3000	2100	10.500
No. of workers laid-off	2	–	13	20	–	–	
Lay off cost	800	–	5200	8000	–	–	14,000

Plan II (Use overtime and idle time) (based on constant 20-work force)

	Jan	Feb	Mar	April	May	June	Total (in Rs.)
Production Required	310	540	380	40	220	320	
Production hrs. Required	3100	5400	3800	400	2200	3200	
Available Hrs./worker	176	152	168	168	176	160	
Total Available Hrs.	3520	3040	3360	3360	3520	320	
O.T. hrs. Required		2360	440	–		0	
O.T. Premium	–	7080	1320	–	–	0	8,400
Idle hours	420	–	–	2960	1320	0	
Idle Time Cost	2520	–	–	17,760	7920	0	28,200

Plan III (Used inventory and stockouts on a constant 20 - worker force)

	Jan	Feb	Mar	April	May	June	Total (in Rs.)
Production Required	310	540	380	40	220	320	
Cumulative Requirement	310	850	1230	1270	1490	1810	
Available Hours	3520	3040	3360	3360	3520	3200	
Unit produced	352	304	336	336	352	320	
Cumulative Production	352	656	992	1328	1680	2000	
Units Short	—	194	238	—	—	—	
Shortage cost	—	3880	4760	—	—	—	
Excess units	42	—	—	58	190	190	8,640
Inventory Cost	84	—	—	116	380	380	960

Note that Plan III assumes that a stockout cost is incurred if safety stock is not maintained at prescribe level of 20% of forecast. The firm is in effect managing the safety stock level to yield a specified degree of production by absorbing the cost of carrying the safety stock as a policy decision.

Summary:

Plan I - 10,500 (Hiring) + 14,000 (Layoff) = Rs.24,500

Plan II - 8,400 (OT) + 28,200 (IT) = Rs. 36,600

Plan III - 8,640 (Stockout) + 960 (Inventory) = Rs. 9,600

Thus, Plan III is the preferred plan.

Problem: 19

X Garment Products produces garment. While planning for next year production following demand (quarterwise) pattern was noticed.

Quarter	I	II	III	IV
Demand	7000	10000	9000	10000

At present it is running in single shift operation having rate of production 80 units. As and when required X.G.P. runs a second shift by hiring extra workers, in which the production is only 60 units. The extra workers, once hired, must be kept for any period equal to a quarter or its' multiples. There is also a provision for giving over time to the workers, which is limited to 25% of the regular hours. However, the O.T. provision is only for the quarters where the production is run in a single shift. The productivity during O.T. is 20% more than that during regular time. The O.T. wages are quite attractive, being at a premium of 50% over the normal wages, which are Rs. 150 per day. X.G.P pays the same wages to all its workers including the temporary ones hired for the second shift. In each shift 20 workers are required.

The cost of change over from a single shift working to double shift working is Rs.30000, and that from a double shift to a single shift working is only Rs.20000 These change over costs are onetime costs, incurred only at the time the shift working changes are made.

The cost accounting section has worked out the inventory holding cost for the products which comes to Rs.30 per unit per month. A quarter is of three months and every month consists of approximately 25 working days.

X.G.P.'s back ordering costs in it are quite heavy, at Rs. 100 per unit per month. An order once delayed can only be accepted in the next quarter or one next to it, i.e. multiple of a quarter.

There is an initial inventory of 1000 units, which is the amount of safety stock that is required to be kept at all times.

Compute and compare the aggregate production plans which provide for:

1. Production at a continuous rate of 9000 units per quarter.
2. Running a single-shift for the first half of the year and a double shift for the second half of the year. (Wherever possible, use OT to the maximum)

Solution:

(i) Aggregate Plan-I (Constant rate of production)

In single shift possible unit/quarter=80 units/day × 75day/quarter=6000 units /quarter

Which is not sufficient to reach constant 9000 units/quarter

So OT option may be explored

= (25 ÷100 × 75 day/quarter) × (120/100) × 80 units/day = 1800 units/quarter.

By inclusion of OT option it was not possible to reach 9000 unit/quarter.

Introducing 2nd shift operation:

The production per quarter = 60 units /day × 75days/quarter = 4500units/quarter

As per given condition as 2nd shift operation is put in force option of O.T. to be discarded.

Thus total production possible in double-shift = 6000+4500 units/quarter.

The relevant cost of 9000 unit per quarter. Regular time wages = 20 × 2 × 150 × 75 = Rs.4,50,000 Cost of change over from single shift to double shift = Rs.30,000/-

Cost of inventory carrying

Quarter	1	2	3	4
Opening (inventory)	1000	3000	2000	2000
Production–(units)	9000	9000	9000	9000
Demand–(units)	7000	10000	9000	10000
End inventory–(units)	3000	2000	2000	1000
Average inventory (units)	2000	2500	2000	1500
Cost of carrying inventory (Rs)	30×3×2000	30×3×2500	30×3×2000	30×3×1500
	=1,80,000	=2,25,000	=1,80,000	= 1,35,000

The total relevant costs over the entire planing

= Regular time wage for year + O.T. + Costs of changeover + inventory cost + Backlog costs

= Rs.4,50,000×4 + 0 + Rs.30,000 + Rs. 1,80,000 + Rs.2,25,000 + Rs. 1,80,000 + Rs. 1,35,000 + 0

= Rs.25,50,000

Aggregate Plan 2 (Single shift for quarter I & II, double shift for quarter III and IV, O.T. to be used to maximum)

Production Plan				
Quarter	1	2	3	4
Regular time production	6000	6000	10500	10500
O.T.	2400	2400	–	–

Quarter-I

Production	8400
Opening invetory	1000
	9400 units
Demand	7000
Inventory at the end of quarter	2400 units

Average inventory at the end of quarter = (1000 + 2400) ÷2 = 1700 units.

Quarter-II

Production	8400
Opening invetory	2400
	10800 units
Demand	10000
Inventory at the end of quarter	800 units

[Here the stock is lower than safety stock] Average inventory

= (2400 + 800) ÷ 2 = 1600 units

Quarter-III

Now the safety stock has to be made up to the 1000 units, i.e. 200 units (1000-800) are demanded over 9000 unit demanded.

Production	8400
Beginning invetory	2400
	10800 units
Demand	10000
Inventory at the end of quarter	800 units

Average inventory = (800 + 1300) ÷ 2 = 1050 units.

Quarter -IV

Production	8400
Initial invetory	2400
	10800 units
Demand	10000
Quarter End inventory	1300 units

Average inventory = (1300+1800) ÷ 2 = 1550 units.

The relevant costs for aggregate plan-2 Regular time wages

= 2 single shift + 2 double shift

= 2,25,000×2+4,50,000×2 = Rs. 13,50,000

Overtime wages for 1st 2 quarters = 225000 × (25/100) × (150/100) × 2

= Rs. 168750

Inventory carrying cost = 3 × 30× (1700+ 1600+ 1050+1550)

= Rs. 5,31,000

Change over cost = Rs. 30000

Total relevant cost = Rs.(13,50,000+1,68,750 + 5,31,000 + 30,000)

= Rs. 20,79,750

The aggregate plan-2 is less costly.

Problem: 20

Machines A and B are both capable of manufacturing a product. They compare as follows:

	Machine A	Machine B
Investment	Rs. 50,000/–	Rs. 80,000/–
Interest on capital invested	15% per annum	15% per annum
Hourly charges (Wages + Power)	Rs. 10/–	Rs. 8/–
No. of pieces produced per hour	5	8
Annual operating hours	2,000	2,000

(i) Which machine will have the lower cost per unit of output, if run for the whole year?

(ii) If only 4000 pieces are to be produced in a year, which machine would have the lower cost per piece?

(iii) Will your answer to (i) above vary if you informed that 12.5% of the output of machine B gets rejected at the inspection stage. If so, what would be the new solution?

Solution:

Data	Machine A	Machine B
Annual interest charges	Rs. $50{,}000 \times \frac{15}{100}$ = Rs.7,500/–	Rs. $80{,}000 \times \frac{15}{100}$ = Rs. 12,000/–
Annual operating charges	Rs. 10×2,000 = Rs. 20,000	Rs. 8 × 2,000 = Rs. 16,000
Total annual charge	7,500 + 20,000 = Rs. 27,500	12,000 + 16,000 = Rs. 28,000
Annual production (units) for 2000 hours	5 ×2,000 = 10,000 nos	8 ×2,000 = 16,000 nos
Cost per unit	$= \frac{27{,}500}{10{,}000}$ = Rs2.75	$= \frac{28{,}000}{16{,}000}$ = Rs1.75

Machine 'B' gives the lower cost per unit if run for the whole year (for 2000 hours),

(ii) If only 4000 pieces are to be produced in an year:

Data	Machine A	Machine B
Operating hours required for	$\frac{4,000}{8}$ =500hrs.	$\frac{4,000}{8}$ =500hrs.
Operating charges Interest charges	Rs. 10×500= Rs. 5,000/– Rs. 7,500/–	Rs.8 × 500 =Rs.4,000/– Rs. 12,000/–
Total annual charges	Rs.(5000 + 7500) = Rs. 12,500	Rs.(4000 + 12000) = Rs. 16,000
Cost per unit	= Rs.3.125/–	= Rs. 4/–

Machine 'A' gives lower cost per unit.

(iii) If 12.5% of output of Machine B is rejected, net annual production

from Machine B = $16,000 \times \frac{(100-12.5)}{100} = 16,000 \times \frac{87.5}{100} = 14,000$

Cost per unit = $\frac{28,000}{14,000}$ = Rs. 2/-

Even though, unit cost of production on Machine B increases from Rs. 1.75 to Rs. 2.0, still machine B continues to be cheaper, if used for 2000 hours in the year.

Problem:21

Methods P and Q are both capable of manufacturing a product. They compare as follows

Data	Method P	Method Q
Fixture – cost	Rs. 24,000/–	Rs. 16,000/–
– life	6 months	4 months
Tooling – cost	Rs. 2,500/–	Rs. 4,800/–
– life	300 pieces	500 pieces
Processing time per piece	6mts	4 mts

The annual requirement is 1500 nos. Operating cost per hour of the process is Rs. 128 for both processes. Material cost is same in each case.

Which method would you choose for production during a period of one year?

Solution:

Data	Method P	Method Q
Cost of manufacture per year Fixture cost	Rs. 24,000 x 2 = Rs. 48,000/–	= Rs. 48,000/– Rs. 16,000x3

(2 nos of fixtures are required per year in method P and 3 nos required in method Q)		
Tooling cost	$= 2{,}560 \times \dfrac{\text{Rs.}1{,}500}{300}$	$= 4{,}800 \times \dfrac{\text{Rs.}1{,}500}{300}$
	= 2560 x5	= 4800 x 3
	= Rs.12,800	= Rs.14,400
Operating hours to produce 1500 nos.	$\dfrac{1500 \times 6}{60}$ =150hrs.	$\dfrac{1500 \times 4}{60}$ =100hrs.
Operating cost per year	Rs. 128x150 = Rs. 19,200/–	Rs. 128x100 = Rs. 12,800/–
Total manufacturing cost per year	Rs. 48,000 /–	Rs. 48,000 /–
	Rs. 12,800 /–	Rs. 14,400 /–
	Rs. 19,200 /–	Rs. 12,800 /–
	Rs. 80,000 /–	Rs. 75,200 /–

Since method Q is cheaper than method P, method 'Q' is the choice for production during the whole one year/period.

2.4 Process Planning

A process is a sequence of activities that is intended to achieve some result, typically to create added value for the customers.

Types of Processes:

(i) Conversion Processes i.e., converting the raw materials into finished products (for example, converting iron ore into iron and then to steel). The conversion processes could be metallurgical or chemical or manufacturing or construction processes.

(ii) Manufacturing Processes can be:

(a) Forming Processes, (b) Machining Processes and (c) Assembly Processes.

(iii) Testing Processes which involve inspection and testing of products (some times considered as part of the manufacturing processes).

Forming Processes include foundry processes (to produce castings) and other processes such as forging, stamping, embossing and spinning. These processes change the shape of the raw material (a metal) into the shape of the work piece without removing or adding material.

Machining Processes comprise metal removal operations such as turning, milling, drilling, grinding, shaping, boring etc.

Assembly Processes involve joining of parts or components to produce assemblies having specific functions.

Process Planning is defined as the systematic determination of methods by which a product is to be manufactured economically and competitively. It consists of selecting the proper machines, determining the sequence of operations, specifying the inspection stages, and tools, jigs and fixtures such that the product can be manufactured as per the required specification. The detailed process planning is done at each component level.

After the final design of the product has been approved and released for production, the Production Planning and Control department takes the responsibility of Process Planning and Process Design for converting the product design into a tangible product. As the process plans are firmly established, the processing time required to carryout the production operations on the equipments and machines selected are estimated. These processing times are compared with the available machine and labour capacities and also against the cost of acquiring new machines and equipments required, before a final decision is made to manufacture the product completely in house or any parts or sub assemblies must be outsourced.

In transformation of raw materials into finished products, several questions need to be answered; such as:

1. What will be the production quantity?
2. What are characteristics of the products to be manufactured?
3. The availability of equipment and what kinds of equipment are to be purchased and what will be the investment?
4. What kinds of labour are required?
5. What should be the level of automation?

6. Make or buy the components required?

Once these questions are answered, the process planning activity can be carried out with minute details as to how each component can be manufactured.

Process Planning is concerned with planning the conversion processes needed to convert the raw material into finished products. It consists of two parts – (i) Process design and (ii) Operations design.

The two terms are explained as under:

Process planning establishes the shortest route that is followed from raw material stage till it leaves as a finished part or product.

The activities that are associated with process planning are:

- List of operations to be performed and their sequence.
- Specifications of the machines and equipment required.
- Necessary toolings, jigs and fixtures.
- Gives the manufacturing details with respect to feed, speed, and depth of cut for each operation to be performed.
- It gives the estimated or processing time of operations.

All the above information is represented in the form of a document called process sheet or route sheet.

The information given in the process sheet can be used for variety of activities.

- It becomes the important document for costing and provides the information on the various details like set-up and operation times for each job.
- The machine and manpower requirements can be computed from the set-up and operational times.
- Helps to carryout scheduling.
- The material movement can be traced.
- It helps in cost reduction and cost control.
- It helps to determine the efficiency of a work centre.

Factors affecting process planning

(i) Volume (quantity) of production.

(ii) Delivery dates for components or products.

(iii) Accuracy and process capability of machines.

(iv) The skill and expertise of manpower.

(v) Material specifications.

(vi) Accuracy requirements of components or parts.

Steps in Process Planning

1. Detailed study of the component drawings to identify the salient features that influence process selection, machine selection, inspection stages and toolings required.
2. List the surfaces to be machined.
3. The surfaces to be machined are combined into basic operations. This step helps in selection of machines for operation.
4. Determine the work centre, tools, cutting tools, jigs and fixtures and inspection stages and equipment.
5. Determine the speed, feed and depth of cut for each operation.
6. Estimate the operation time.
7. Find the total time to complete the job taking into account the loading and unloading times, handling times, and other allowances.
8. Represent the details on the process sheet.

Process design is concerned with the overall sequences of operations required to achieve the product specifications. It specifies the type of work stations to be used, the machines and equipments necessary to carryout the operations. The sequence of operations is determined by (a) The nature of the product, (b) the materials used, (c) the quantities to be produced and (d) the existing physical layout of the plant.

Operations design is concerned with the design of the individual manufacturing operation. It examines the man-machine relationship in the manufacturing process. Operations design must specify how much labour and machine time is required to produce each unit of the product.

Process Design-Framework

The process design is concerned with the following: (i) Characteristics of the product or service offered to the customers, (ii) Expected volume of output, (iii) Kinds of equipments and machines available in the firm, (iv) Whether equipments and machines should be of special purpose or general purpose, (v) Cost of equipments and machines needed, (vi) Kind of labour available, amount of labour available and their wage rates, (vii) Expenditure to be incurred for manufacturing processes, (viii) Whether the process should be capital-intensive or labour-intensive, (ix) Make or buy decision and (x) Method of handling materials economically.

Selection of process

Process selection refers to the way production of goods or services is analysing. It is the basis for decisions regarding capacity planning, facilities (or plant) layout, equipments and design of work systems. Process selection is necessary when a firm takes up production of new products or services to be offered to the customers.

Three primary questions to be addressed before deciding on process selections are:

- How much varieties of products or services will the system need to handle?
- What degree of equipment flexibility will be needed?
- What is the expected volume of output?

Process decisions:

Major process decisions are:

Process choice :

It refers to choice of a particular process, based upon the nature of product. The operations manager has to choose from five basic process types – (i) Job shop, (ii) Batch, (iii) Repetitive or assembly line, (iv) Continuous and (v) Project.

Vertical integration :

Vertical integration is the degree to which a firm's own production system handles the entire supply chain starting from procurement of raw-materials to distribution of finished goods.

Two directions of vertical integration are:

(a) Backward integration which represents moving upstream toward the sources of raw-materials and parts, for example, a steel mill going for backward integration by owning iron ore and coal mines and a large fleet of transport vehicles to move these raw materials to the steel plant.

(b) Forward integration in which the firm acquires the channel of distribution (such as having its own warehouses, and retail outlets).

Procedure for process planning and design

1. The inputs required comprise the product design information, production system information and product strategy decisions.
2. Process planning and design starts with selection of the types of processes, determining the sequence of operation, selection of equipment, tooling, deciding about the type of layout of facilities and establishing the control system for efficient analysing of resources to achieve most economical production of the product.
3. The outputs are specific process plans, route sheets, flow charts, assembly charts, installation of equipments, machinery, material handling systems and providing trained, skilled employees to carryout the production processes to achieve the desired results.

Process analysis and process flow design :

While analysing and designing processes to transform input resources into goods and services, certain questions need to be asked. They are:

- Is the process designed to achieve competitive advantage in terms of differentiation, response or low cost?
- Does the process eliminate steps that do not add value?
- Does the process analysing customer value as perceived by the customer?
- Will the process enable the firm to obtain customer orders?

A number of tools help production manager to understand the complexities of process design and redesign.

Some of such tools are: (i) Flow diagram, (ii) Assembly charts, (iii) Process charts and (iv) Operation and Route sheet.

These tools are discussed in the following paragraphs.

Flow Diagrams: It is a drawing used to analyse the movement of people or material or product to understand, analyse and communicate the process to others.

Assembly Charts: Assembly charts are used to provide an overall macro view of how materials and sub assemblies are assembled to form finished products. These charts list all major materials, components, sub assembly operations, inspections and assembly operations.

Process Charts: A process chart is understood as a graphic representation of events and information relating to them during a series of actions or operations.

Operation process charts are similar to assembly charts except that they include specifications for the components as well as operating and inspection times and thereby provide more instruction on how to produce an item.

The operation analysis and routing sheets or simply the route sheets specify precisely how to produce an item by identifying the equipment and tools to be used, the operations to be carried out and their sequence to be followed and the machine set up and run-time estimate.

Purpose of Process Charts

Process charts can present a picture of a given process so clearly that every step of the process can be understood by those who study the charts.

Process charts may be effective in process analysis and may help in detecting inefficiencies of the processes currently adopted.

Types of Process Charts

Process charts can be classified as operation process charts, flow process charts, worker-machine/man-machine charts and activity charts or multiple activity charts.

(a) Operation Process Chart

Operation process chart, the basic process chart is a graphic representation of the points at which materials are introduced into the process and of the sequences of inspections and all operations except those involved in material handling. It includes information considered desirable for analysis such as time required and location.

Flow Process Chart

Flow process chart is a graphic representation of all operations, transportations, inspections, delays and storages during a process and includes information for analysis such as time required and distance moved.

It is especially useful in detecting hidden, non-productive costs such as delays, temporary storages and distances travelled.

Worker-Machine Chart or Man-Machine Chart or Multiple Activity Chart

Worker-machine charts or man-machine charts are graphical representation of simultaneous activities of a worker and the machine or equipment he or she operates. These charts help identify idle time and cost of both workers and machines. Alternative worker-machine combinations can be analysed to determine the most efficient arrangement of worker-machine interaction for carrying out a job.

Worker-machine charts show the time required to complete tasks that constitute a work cycle. A cycle is the length of time required to progress through one complete combination of work activities.

Operation Analysis and Route Sheet: An operation and route sheet specifies operations and process routing for a particular part and assembly. It conveys such information as the type of equipment, tooling, and operations required to complete the part, equipment setup time and operation time etc.

Process improvement

It is a systematic study of the activities and flows of each process to improve the process. Once the process is thoroughly understood, it can be improved.

Process improvement becomes necessary because of relentless pressure to provide better quality at a lower price. The basic techniques for analysing the processes such as flow diagrams and process charts are useful for understanding the processes and improve them. Improvements can be made in quality, through-put time, cost, errors, safety and on-time delivery.

Process improvement is necessary when:

(i) the process is slow in responding to the customer,

(ii) the process introduces too many quality problems or errors,

(iii) the process is costly,

(iv) the process is a bottleneck, with work accumulating and waiting to go through it, and

(v) the process involves waste, pollution and little value addition.

Application of BCA in the choice of machines or process

This analysis is the most convenient method for selecting the optimum method of manufacture or machine amongst the competing ones. The cost estimates of the competing methods (both fixed and variable costs) are prepared and a particular quantity N is determined at which the alternatives give the same cost.

If the quantity to be manufactured is less than N the process with lower fixed cost is selected and if the quantity to be produced is more than N the process with lower variable cost is selected.

Let F_A the Annual Fixed Cost of Machine A

F_B the Annual Fixed Cost of Machine B

V_A – Variable Cost per unit for Machine A

V_B = Variable Cost per unit for Machine B

N = Quantity at which costs on both machines will be equal.

$\therefore$ Total cost on machine A = Total cost on Machine B for Quantity N

i.e., $F_A + V_A.N = F_B + V_B.N$

or, $N(V_A - V_B) = F_B - F_A$

or, $N = \dfrac{F_B - F_A}{V_A - V_B}$

The alternative with lower fixed cost will be more economical for manufacturing up to N and once the quantity exceeds N, it is economical to select an alternative with lower variable cost.

Problems and Solutions

Problem 1:

A component can be manufactured either on centre lathe or on a turret lathe. The cost and time information to process a component is given below.

Particulars	Centre lathe	Turret lathe
▪ Setup time	30 minutes	120 minutes
▪ Processing time	10 minutes	5 minutes
▪ Tooling up cost (Rs.)	200	500
▪ Labour cost/hr	Rs. 2	Rs. 2
▪ Depreciation and other cost per hour	Rs. 10	Rs. 20

The tooling costs are to be recovered within a year. There are no repeat orders. The requirements are to be met in two lots.

(i) Find the quantity at which both alternatives results in equal cost. (BEP)

(ii) Give the decision rule regarding the choice of lathes

(iii) If the quantity required is 800 Nos./year, which of the machine do you propose?

Solution:

Let F_1 = Fixed cost for the centre lathe. Fixed cost consists of set-up and tooling up costs.

∴ Fixed cost for centre lathe (F_1) = Set-up cost + Tooling up cost

∴ F_1 = No. of set-ups/year × set-up time/set-up (hrs) × [(set-up labour rate) + (Depreciation and other expense/hr)] + tooling up costs.

$$= 2 \text{ x } \frac{30}{60} \text{ x } (10 + 2) + 200 = 212 \text{ (Rs.)}$$

Similarly, Fixed cost of turret lathe (F_2) = $\frac{2 \times 90}{60}$ x (20 + 2) + 500= Rs. 566

Variable cost for centre lathe = V_1

V_1 = Processing time × [(Labour cost/hr + Depreciation and other cost/hr)]

$$= \frac{10}{60} (10 + 2) = \text{Rs. } 2 \text{ / piece}$$

Variable cost for turret (V_2)

$$V_2 = \frac{5}{60} (20 + 2) = 1.83 \text{ Rs. /piece.}$$

Let, Quantity at which both alternatives gives equal cost be 'N'.

$$N = \frac{F_2 - F_1}{V_1 - V_2} = \frac{566 - 212}{2 - 1.83} = \frac{354}{0.17} = 2082.3 = 2083.$$

Thus the break-even quantity is 2083 pieces.

2. Decision Rule

(i) If quantity is below 2083, Centre lathe is preferred because of lower fixed cost.

(ii) For quantities above 2083, turret lathe is preferred.

(iii) For quantity 2083, both are equally feasible select either of the two machines.

Problem 2:

A Company's fixed and variable costs for manufacturing a component on three alternative machines are given below formulate the decision rules for selecting the machines.

	Fixed Cost (Rs.)	Variable Cost (Rs/unit)
Engine lathe	5	0.20
Capstan lathe	30	0.10
Automat	70	0.05

Solution:

The total cost = fixed cost + [variable cost / unit × no. of units]

Let, Tc_1 , Tc_2 and Tc_3 be the total costs for engine lathe, capstan lathe and automat respectively

Let, 'x' be the number of units to be manufactured Then,

Total cost on Engine lathe (Tc_1) = 5 + 0.2x

Total cost on Capstan lathe (Tc_2) = 30 + 0.lx

Total cost on Automat (Tc_3) = 70 + 0.05x

Now, comparing the Tc_1 and Tc_2.

$\therefore$ 5 + 0.2x = 30 + 0.lx

$\therefore$ 0.lx = 25

x = 250

Comparing the Tc_2 and Tc_3

At B.E.P. Tc_2 = Tc_3

$\therefore$ 30 + 0.1x = 70+0.05x

$\therefore$ 0.05x = 40

$\therefore$ x = 800

Decision Rules

(i) If the quantity is below 300, select engine lathe

(ii) Between 300 to 800, select capstan lathe

(iii) Above 800, Automat is to be selected.

Problem 3 :

A Job is performed on the milling machine. The following details are given below:

Standard time for job = 6 minutes

No. of jobs to be produced = 70,000 jobs

Machine capacity = 2000 hrs/month

Machine utilisation = 90%

Compute the number of machines required.

Solution:

$$\text{Standard Time (ST)} = \frac{6}{60} = \frac{1}{10} \text{ hrs.}$$

Maximum Production (MP) = 70,000

Machine Capacity (MC) = 2000 hrs/month

Utilisation of capacity (UC) = 0.9

$\therefore$ No. of Machines required (N)

$$N = \frac{ST \times MP}{MC \times UC} = \frac{0.1 \times 70,000}{2,000 \times 0.9} = 3.88 \text{ Machines} = 4 \text{ Machines}$$

Problem 4:

A company wants to expand the solid propellant manufacturing plant by the addition of more 1 tonne capacity curing furnace. Each tonne of propellant must undergo 30 minutes of furnace time including loading and unloading operations. Furnace is used only 80 per cent of the time due to power restrictions. The required output for the new layout is to be 16 tonnes per shift (8 hours). Plant efficiency (system) is estimated at 50 per cent of system capacity.

(a) Determine the number of furnaces required

(b) Estimate the percentage of time the furnace will be idle

Solution

$$\text{Required system capacity} = \frac{\text{Actual output}}{\text{System Efficiency}}$$

$$= \frac{16 \text{ tonnes/shift}}{0.5}$$

$$= 32.0 \text{ tonnes/shift}$$

$$\text{Reared system capacity (hrs)} = \frac{32 \text{ tonnes / shift}}{0.8 \times 8 \text{ hrs / shift}} = 5 \text{ tonnes/hrs.}$$

$$\text{Individual furnace capacity} = \frac{1 \text{ tonne}}{0.5 \text{hr}} = 2 \text{ tonnes / hr per furnace}$$

(i) Number of furnaces required (N) = $\dfrac{\text{Required furnance capacity}}{\text{Individual furnace capacity}}$

$$N = \frac{5\text{ tonnes / hr}}{2\text{ tonnes / hr / per furnace}} = 2.5 \text{ furnaces (say 3)}$$

(ii) Total Hours available per shift = 3 furnace @ 8 hours = 24 furnaces hrs

(iii) Total Hours of actual use per shift =16 tonnes × 0.5 hr/tonne = 8 furnace hr

Idle hours = 24 - 8 = 16 hours

Percentage idle time = $\dfrac{5\text{hrs idle}}{2\text{hrs total}}$ = 66.66% ≈ 67% Idle time.

Problem 5:

A lathe machine is used for turning operation and it takes 30 minutes to process the component. Efficiency of the lathe is 90 per cent and scrap is 20 per cent. The desired output is 600 pieces per week. Consider 48 hours per week. Determine the number of lathes required?

Solution

Assuming 50 weeks in a year.

≈

The output per annum = 600 × 50 = 30,000 units.

The scarp rate is 20%.

∴ The quantity to be produced (including scarp)

$$\frac{\text{Required output}}{(1-\text{Scraprate})} = \frac{30,000}{(1-0.2)} = 37,500 \text{ units}$$

Total time required for turning

$$= 37,500 \times \frac{30}{60} = 18,750 \text{ hours}$$

Production time required with 90 per cent efficiency

$$= \frac{18,750}{0.9} = 20833.3 \text{ hours}$$

Time available per lathe per annum = 48 × 50 = 2400 hrs

$$\therefore \text{Number of lathes required} = \frac{\text{Time required (hrs)}}{\text{Time available (hrs)}} = \frac{20833.3}{2400} = 8.68 \approx 9$$

∴ No. of lathes required = 9

Problem 6:

An article is processed on three machines A, B and C as shown below:

Machine	Machine operation time			Preparation time (min/day)	Cleaning (min/day)
	Time	Processing	Total		
A	2	2.5	4.5	15	10
B	3	10	13	30	10
C	2	5	5	35	10

A study revealed that if the jigs for machines B and C were to be redesigned, loading and unloading times could be reduced to 2 minutes and 1 minute respectively.

(a) Find the number of pieces produced per day (single shift of 8 hrs).

(b) Costing has shown that unless production is increased by 20 per cent the installation of new jigs would not be worthwhile. Would you recommend redesign of jigs.

(c) If the number to be produced is large, suggest changes in present arrangement and estimate new production rate.

Solution:

Machines	Processing time (minutes)	Preparation and cleaning (min/day)
A	2 + 2.5 = 4.5	25
B	3 + 10 = 13	40
C	2 + 5 = 7	35

(a) Cycle time for the job is 13 minutes.

Total production-time available/day = 480 - preparation and cleaning time/day

For machine B (critical operation) = 480 – 40 = 440 min= 440/13

Output/day = 34 pieces

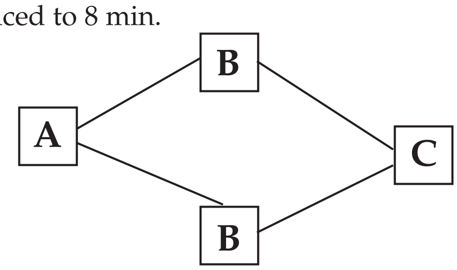
(b) ***Redesigning the new jigs:*** The redesigning of new jigs will change the cycle time, i.e., the cycle time is reduced to 12 minutes (from 13 min as the unloading and loading time is reduced by 1 minute)

Output/day = 440/12 = 36.6 = 37 pieces

$$\text{Percentage increase in output} = \frac{37-34}{34} \times 100\ \% = 9\%$$

So the redesign of jigs is not justified.

(c) ***Suggestion if the number of pieces is large:*** The critical operation (bottleneck) is processing on machine B which requires 10 minutes. If we introduce one more machine of kind B, then the cycle time will be reduced to 8 min.



The new output = $\frac{440}{8}$ = 55 pieces.

Problem 7:

A component is to be processed on two machines lathe and milling machine. The sequence of operation is first turning and then milling.

The machine times are given below:

Turning 12 minutes.

Milling 20 minutes.

1. Estimate the number of machines required to machine 2500 components per week if available machine hours per week are 48.
2. What are the steps that you propose to reduce number of machines.

Solution:

1. No. of components required to be machined = 2500/week

   The available time (in hr.) per week = 48

   Assuming 50 weeks in a year, no. of components to be machined/annum = 2500 × 50 = 1,25,000 annum.

   The time required to machine 1,25,000 components = 1,25,000 × $\frac{12}{60}$ = 25,000 hrs

   Time available per annum = 48 × 50 = 2400 hrs

   No. of lathes required = 10.41 $\approx$ 11

No. of milling machines required = $\dfrac{12,000 \times \frac{20}{60}}{2400} = 17.36 \approx 18$

2. Steps to reduce the number of machines. Increase the number of shifts. Addition of second shift is going to reduce the number of machines by 50 per cent.

Problem 8:

The component can be processed on either of the two machines — Turrette lathe and Center lathe. The time and cost details are given below.

Computer the breakeven quantity and state the decision rules.

Particulars	Turrette Lathe	Centre Lathe
1. Setup time (hrs)	4.5	0.2
2. Operation time/piece (min)	4.0	35
3. Setup cost/hour (Rs.)	350	15
4. Machining cost/hour (Rs.)	45	25

Solution:

Breakeven quantity refers to the quantity at which both the alternatives are equally feasible and the total cost of both alternatives are equal

Let 'Q' be the breakeven quantity

Total cost of production on Turrette lathe = Total cost of production on center lathe

= [Setup cost + operation cost] $_{\text{Turret}}$ = [Setup cost + operation cost]$_{\text{Center}}$

$$= [4.5 \times 350] + \left[\frac{4}{60} \times Q \times 45\right] = [0.2 \times 15] + \left[\frac{35}{60} \times Q \times 25\right]$$

or, 1575 + 3Q = 3 + 14.58Q

or, 11.58Q = 1572

or, Q = 136 units.

If the quantity is ≤ 136, Center lathe is preferred.

If the quantity is ≥ 136, Turrette Lathe is preferred.

Problem 9:

A customer is processed through each of the three operations A, B and C, in sequence. The process is designed to handle 100 customers a day. The average rate at which each operation can process customers is shown in the figure below:

$$\longrightarrow \boxed{A} \longrightarrow \boxed{B} \longrightarrow \boxed{C}$$

15 Customer /hr   10 Customer /hr   12 Customer /hr

(a) For an 8 hour day identify any bottlenecks in the process.

(b) What effect will bottlenecks have on overall output and other operations?

(c) If all the processes are operated for 10 hours per day, is there still a bottleneck?

(d) How will random arrivals affect the output and processing rate of this process?

Solution:

(a) Identification of bottleneck for an 8 hour a day operation.

Operation A, Output for 8 hrs/day = 15 × 8 = 120 customers

Operation B, Output for 8 hrs/day = 10 × 8 = 80 customers

Operation C, Output for 8 hrs/day = 12 × 8 = 96 customers

Looking into the above calculations, the operations B which process 10 customer/hr and 80 customers a day becomes the bottleneck.

(b) Effect of the bottleneck on the overall output.

The bottleneck operation decides the capacity and output. Here the capacity of the unit is 80 customer/day (due to bottleneck B) even though the process A and C have the output of 120 and 96 respectively.

(i) Effect of the bottleneck on other operation. Bottleneck operation B, makes the waiting time higher for C. Because of difference in out (C > B), facility has to wait fill the customer comes from B.

(ii) In case A, the operation will be completed and because of difference in processing rates, operation A will be idle for 25% time unless it is used for other purpose and the full capacity of A if used creates an inventory between A and B.

(c) If all the processes are operated for 10 hrs, then the designed output of 100 customers/hr. are achieved still the process line is unbalanced as the processing capacities are unequal.

(d) Random arrivals affect the output and processing of customers.

The random arrivals affect the capacity utilisation also both capacity idle time and shortage.

2.5 Project Planning

Planning begins with well-defined objectives. The project team may be drawn from several organizational departments, e.g., engineering, production, marketing, and accounting. Project definition involves identifying the controllable and uncontrollable variables involved, and establishing project boundaries. Performance criteria should relate to the project objectives, which are often evaluated in terms of time, cost, and resource utilisation

Project planning is part of project management, which relates to the use of schedules such as Gantt charts to plan and subsequently report progress within the project environment. **Project management** is the discipline of organizing and managing resources (e.g. people) in such a way that the project is completed within defined scope, quality, time and cost constraints. A project is a temporary and one-time endeav or undertaken to create a unique product or service, which brings about beneficial change or added value. This property of being a temporary and one-time undertaking contrasts with processes, or operations, which are permanent or semi-permanent ongoing functional work to create the same product or service over and over again. The management of these two systems is often very different and requires varying technical skills and philosophy, hence requiring the development of project managements.

The first challenge of project management is to make sure that a project is delivered within defined constraints. The second, more ambitious challenge is the optimized allocation and integration of inputs needed to meet predefined objectives. A project is a carefully defined set of activities that use resources (money, people, materials, energy, space, provisions, communication, etc.) to meet the predefined objectives.

Initially, the project scope is defined and the appropriate methods for completing the project are determined. Following this step, the durations for the various tasks necessary to complete the work are listed and grouped into a work breakdown structure. The logical dependencies between tasks are defined using an activity network diagram that enables identification of the critical path. Float or slack time in the schedule can be calculated using project management software. Then the necessary resources can be estimated and costs for each activity can be allocated to each resource, giving the total project cost. At this stage, the project plan may be optimized to achieve the appropriate balance between resource usage and project duration to comply with the project objectives. Once established and agreed, the plan becomes what is known as the baseline. Progress will be measured against the baseline throughout the life of the project. Analysing progress compared to the baseline is known as earned value management.

Gantt Chart: Gantt Chart is a principal tool used in scheduling and also in some methods of loading. This chart was originated by the American engineer Henry L. Gantt and consists of a simple rectangular grid, divided by series of parallel horizontal and verticular lines. The vertical lines always divide the horizontal scale units of time. The time units can be in years, months, weeks, days, hours, minutes or even seconds according to the work for which it is prepared. In this chart, the time which an activity takes in completing the task is represented by the horizontal line. The length of the line is drawn in proportion to the duration of time. Generally, the time in the chart should flow from left to right and activities be listed from top to bottom. The progress of the work may be shown by a bar or a line within the uprights of the activity symbol and its length should represent the amount of work completed. Horizontal lines divide the chart into sections which can represent various work tasks (work schedule) or work centres (load schedule). When it shows only work tasks-products, orders, or operations to be completed, it is known as Work Schedule. When it shows the same task opposite the work centres at which they are produced-factories, departments, workshops, machine tools or men it is known as Load Chart.

The units scheduled or loaded on these charts are always the same because these work tasks are known as having a known standard time. The work tasks can be represented on the chart by numbers or symbols. The symbols used on the chart may van from company to company.

Network Analysis: Routing is the first step in production planning. In small projects, routing is very simple. Sequence of operations is almost decided and the operations can be performed one after the other in a given sequence. But in large project, this is rather a difficult problem. There may be more than one route to complete a job. The function of production manager is to find out the path which takes the least time in completing the project.

In a big project, many activities are performed simultaneously. There are many activities which can be started only at the completion of other activities. In such cases, a thorough study is required to collect the complete details about the project and then to find out a new, better and quicker way to get the work done in a decent way. In such cases, the first step is to draw some suitable diagram showing various activities and their positions in the project. It should also explain the time to be taken in completing the route from one operation to the other. It also defines the way in which the delay in any activity can affect the entire project in terms of both money and time. Such a diagram is called network diagram. A network is a picture of a project, a map of requirements tracing the work from a departure points to the final completion objective. It can be a collection of all the minute details involved or only a gross outline of general functions.

Important characteristics in a Network Analysis: The following are some important points to remember in a network analysis:

(i) The objective is to be finished within the specified time otherwise there is a penalty.

(ii) Various activities are to be completed in an order; however, a number of activities are performed simultaneously while there are many other activities, which can be started only when some other activities are completed.

(iii) The cost of any activity is proportional to its time of completion.

(iv) There can be hurdles in the process and the resources to be allocated may be limited. A network graph consists of a number of points or nodes, each of which is connected to one or more of the other nodes by routes or edges. It is a set of operations and activities describing the time orientation of a composite project.

Procedure for drawing a network diagram: The procedure for drawing a network diagram may be explained below.

There are three basic questions and the network depends on them.

These questions are:

- Which operation must be completed before each given operation can be started?
- Which activities can be carried out in parallel?
- Which operation immediately succeeds other given activities?

The common practice is simply to work backward through the list of operations, generating the immediate predecessors for each operation.

Slack and float:

Slack – Slack signifies the freedom for rescheduling or to start the job. It can be calculated by the difference between EFT and LFT for any job. A job for which the slack time is zero is known as critical job. The critical path can be located by all those activities or events for which slack time is either zero or float time is the least. The abbreviations EFT and LFT given in the above line have the following explanation.

EFT (Earliest Finish Time) – this is the sum of the earliest start time plus the time of duration for any event.

LFT (Latest Finish Time) – It is calculated from the LFT of the head event. For its calculation total project time is required. The total project time is the shortest possible time required in completing the project.

Floats – Floats in the network analysis represent the difference between the maximum time available to finish the activity and the time required to complete it. There are so many activities where the maximum time available to finish the activity is more than the total time required to complete it. This difference is known as floats.

Floats may be total, free, and independent:

Total Float: Total float is the maximum amount by which duration time of an activity can be increased without increasing the total duration time of the project. Total float can be calculated as follows:

(i) First, the difference between Earliest Start Time (EST) of tail event and Latest Finish Time (LFT) of head event for the activity shall be calculated.

(ii) Then, subtract the duration time of the activity from the value obtained in (i) above to get the required float for the activity.

The total float can be helpful in drawing the following conclusions:

(a) If total float value is negative, it denotes that the resources for completing the activity are not adequate and the activity, therefore, cannot finish in time. So, extra resources or say critical path needs crashing in order to reduce the negative float.

(b) If the total float value is zero, it means the resources are just sufficient to complete the activity without any delay.

(c) If the total float value is positive, it points out that total resources are in excess of the amount required or the resources should be reallocated to avoid the delay otherwise the activity will be delayed by so much time.

Free Float: It is that fraction from total float of an activity which can be used for rescheduling the activity without affecting the succeeding activity. If both tail and head events are given their earliest times, i.e., EST and EFT the Free Float can be calculated by deducting head slack from total float, i.e.,

Free Float = Total float - Slack time of the head event.

Independent Float: It is the time by which an activity can be rescheduled without affecting the other activities – preceding or succeeding. It may be calculated as follows:

= Earliest Start Time (EST) - Earliest Finish Time (EFT) of the activity

or, Independent Float = Free Float -Slack Time of tail event. The basic difference between slack and float time is that a slack is used with reference to events whereas float is used with reference to activity.

Use of Float Information in Decision Making: The float information can be used in decision-making in the following ways:

(i) Total float can affect both the previous and the subsequent activities.

(ii) Total float can be used without affecting the subsequent activities.

(iii) Independent float can be used in allocating the resources elsewhere and increasing the time of some non-critical activities.

(iv) Negative float signifies reduction in target time to finish the work in time.

Critical Path Method (CPM): The critical path analysis is an important tool in production planning and scheduling.Gnatt charts are also one of the tools of scheduling but they have one disadvantage for which they are found to be unsuitable. The problem with Gnatt Chart is that the sequence of operations of a project or the earliest possible date for the completion of the project as a whole cannot be ascertained. This problem is overcome by this method of Critical Path Analysis.

CPM is used for scheduling special projects where the relationship between the different parts of projects is more complicated than that of a simple chain of task to be completed one after the other. This method (CPM) can be used at one extreme for the very simple job and at other extreme for the most complicated tasks.

A CPM is a route between two or more operations which minimises (or maximises) some measures of performance. This can also be defined as the sequence of activities which will require greatest normal time to accomplish. It means that the sequence of activities which require longest duration are singled out. It is called at critical path because any delay in performing the activities on this path may cause delay in the whole project. So, such critical activities should be taken up first.

One of the purposes of critical path analysis is to find the sequence of activities with the largest sum of duration times, and thus find the minimum time necessary to complete the project. The critical series of activities is known as the **'Critical Path'**.

Under CPM, the project is analysed into different operations or activities and their relationship are determined and shown on the network diagram. So, first of all a network diagram is drawn. After this the required time or some other measure of performance is posted above and to the left of each operation circle. These times are then combined to develop a schedule which minimises or maximises the measure of performance for each operation. Thus CPM marks critical activities in a project and concentrates on them. It is based on the assumption that the expected time is actually the time taken to complete the object.

Thus CPM technique is a very useful analysis in production planning of a very large project.

PERT (Programme Evaluation and Review Technique):

There are so many modem techniques mat have developed recently for the planning and control of large projects in various industries especially in defence, chemical and construction industries. Perhaps, the PERT is the best known of such techniques.

PERT is a time-event network analysis technique designed to watch how the parts of a programme fit together during the passage of time and events. This technique was developed by the special project office of the U.S. Navy in 1958. It involves the application of network theory to scheduling, problems. In PERT we assume that the expected time of any operation can never be determined exactly.

Major Features of PERT or Procedure or Requirement for PERT:

The following are the main features of PERT:

(i) All individual tasks should be shown in a network. Events are shown by circles. Each circle represents an event—an event —a subsidiary plan whose completion can be measured at a given time.

(ii) Each arrow represents an activity —the time - consuming elements of a programme, the effort that must be made between events.

(iii) Activity time is the elapsed time required to accomplish an event. In the original PERT, three-time values are used as follows:

- t_1 (Optimistic time): It is the best estimate of time if every tiling goes exceptionally well.
- t_2 (Most likely time): It is an estimated time what the project engineer believes necessary to do the job or it is the time which most often is required if the activity is repeated a number of times.
- t_3 (Pessimistic time): It is also an activity under adverse conditions. It is the longest time and rather is more difficult to ascertain.

The experiences have shown that the best estimator of time out of several estimates made by the project engineer is:

$$t = \frac{t_1 + 4t_2 + t_3}{6} \text{ and the variance of t is given by: } V(t) = \left(\frac{t_3 - t_1}{6}\right)^2$$

(iv) The next step is to compute the critical path and the slack time.

A critical path or critical sequence of activities is one which takes the longest time to accomplish the work and the least slack time.

Difference in PERT and CPM - Although these techniques (PERT and CPM) use the same principles and are based on network analysis yet they are in the following respects from each other:

(i) PERT is appropriate where time estimates are uncertain in the duration of activities as measured by optimistic time, most likely time, and pessimistic time, whereas CPM (Critical Path Method) is good when time estimates are found with certainty. CPM assumes that the duration of every activity is constant and therefore every activity is critical or not.

(ii) PERT is concerned with events which are the beginning or ending points of operation while CPM is concerned with activities.

(iii) PERT is suitable for non-repetitive projects while CPM is designed for repetitive projects.

(iv) PERT can be analysed statistically whereas CPM not.

(v) PERT is not concerned with the relationship between time and cost, whereas CPM establishes a relationship between time and cost and cost is proportionate to time.

Problem and Solution

Problem: 1

A small project is composed of time activities whose time estimates are given below:

Activities A, B and C can start simultaneously. Activity D follows activity A while E follows B.

Activity D and E are followed by activity G while F is dependent on C, H depends on D and E, while I

Activity	A	B	C	D	E	F	G	H	I
Optimisctic time	2	2	4	2	2	3	2	5	3
Most likely time	2	5	4	2	5	6	5	8	6
Pessimistic time	8	8	10	2	14	15	8	11	15

depends on F and G.

(i) Construct the network.

(ii) Find the expected duration and variance of each activity.

(iii) Calculate the slack for each event.

(iv) What is the critical path and expected project duration of the project?

(v) The project due date is 28 days, what is the probability of meeting the due date?

(vi) What should be the project duration for the probability of completion of 95%?

Solution:

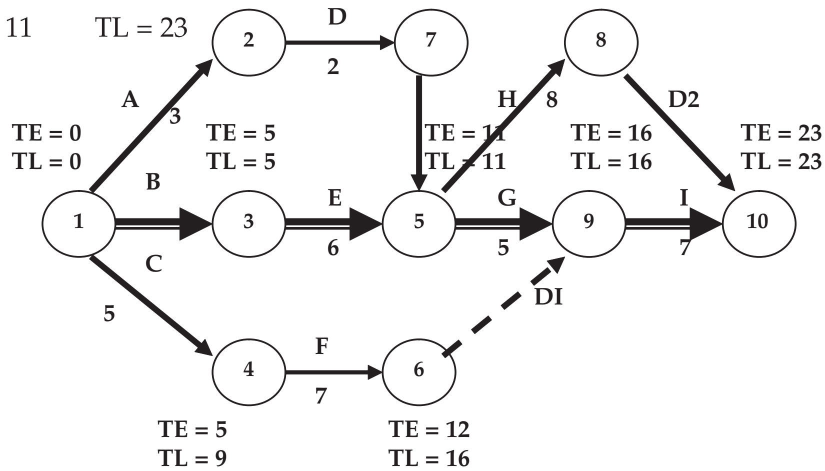
Expected time $T_e = \dfrac{a + b + 4m}{6}$ = and Variance V = $\left(\dfrac{b - a}{6}\right)^2$

Activity	Expected time (T_e)	Variance (v)
A	3	1
B	5	1
C	5	1
D	2	0
E	6	4
F	7	4
G	5	1
H	8	1
I	7	2

Construction of Network

TE = 3 TE = 5 TE =19

TL = 9 TL = 11 TL = 23



Critical path is $\rightarrow 1 \rightarrow 3 \rightarrow 5 \rightarrow 9 \rightarrow 10$

$B \rightarrow E \rightarrow G \rightarrow I$

Project duration 23 days

Standard deviation $\sigma = \sqrt{V_{ij}} = 2.83$

$$Z = \frac{T_s - T_e}{SD} = \frac{28-23}{SD} = 0.833$$

$\therefore$ Probability of completion = 96.16% (approx)

With 95% probability $Z=1.65 = \dfrac{T_s - 23}{SD}$

$\therefore$ Schedule time = 33 days

2.6 Progressing and Follow-up

Expediting or progressing ensures that, the work is carried out as per the plan and delivery schedules are met.

Progressing including activities such as status reporting attending to bottlenecks or hold-ups in production and removing the same, controlling variations or deviations from planned performance levels, following up and monitoring progress of work through all stages of production, co-ordinating with purchase, stores, tool room and maintenance departments and modifying the production plans and re-plan if necessary.

Need for expediting may arise due to the following reasons.

a. Delay in supply of materials.
b. Excessive absenteeism.
c. Changes in design specifications.
d. Change in delivery schedules initiated by customers.
e. Break down of machines or tools and fixtures.
f. Errors in design and process plans.

2.7 Dispatching

Dispatching may be defined as setting production activities in motion through the release of orders work order, shop order and instructions in accordance with the previously planned time schedules and routings.

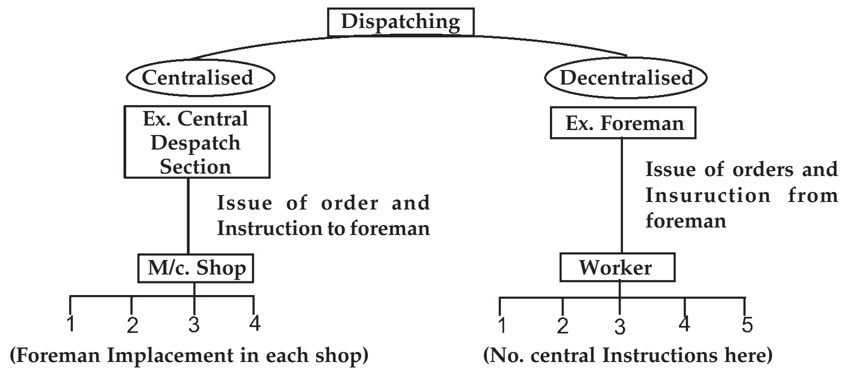


Fig. Dispatching

Dispatching also provides a means for comparing actual progress with planned production progress. Dispatching functions include:

a. Providing for movement of raw materials from stores to the first operation and from one operation to the next operation till all the operations are carried out.

b. Collecting tools and fixtures from tool stores and issuing them to the user department or workers.

c. Issuing job orders authorizing operations in accordance with dates and times as indicated in schedules or machine loading charts.

d. Issue of drawings, specifications, route cards, material requisitions and tool requisitions to the user department.

e. Obtaining inspection schedules and issuing them to the inspection section.

f. Internal materials handling and movement of materials to the inspection area after completing the operation, moving the materials to the next operation centre after inspection and movement of completed parts to holding stores.

g. Returning fixtures and tools to stores after use.

2.8 Scheduling Technique and Line Balancing Problem

Scheduling: 'Scheduling' is the next important function of production planning and control after 'Routing'. It determines the starting and the completion timings for each of the operations with a view to engage every machine and operator of the system for the maximum possible time and; without imposing unnecessary burden over them. Scheduling is the determination of the time that should be inquired to perform each operation and also the time that should be required to perform the entire series as routed. Scheduling involves establishing the amount of work to be done and the time when each element of the work will start or the order of the work.

Scheduling technique is an important technique of determining the starting and the completion timings of each operation and that of the total manufacturing process so that the man and machines can be utilised to the maximum.

Scheduling depends upon a number of factors, e.g., routing, the method of production, quantity of production, transportation of raw materials, production capacity, the probable data of delivery specified by customers in their orders and the past records.

Relationship between 'Routing' and 'Scheduling'. 'Routing' and 'Scheduling' are independent and either of these activities cannot be undertaken independently. It is very difficult to prepare schedules without determining the routing of sequence of operations. Routing is the prerequisite of scheduling. Unless route or sequence of operations, tools, equipment and plants and the persons by when operations are to be performed, are established, the time taken by each operation, the idle time of men and machine and total time for the whole process cannot be ascertained in a convincing manner.

Conversely, scheduling is equally important for routing. It is quite difficult to route an item efficiently through a plant without consulting previously-designed schedules. The main aim of routing is to pass the item through the process of manufacture by a route which is the best and the most economical. And a route or sequence of operations may be considered best which utilises the men, materials and machines to the maximum and which consumes the shortest time during the process of production. This information (time schedule of each operation) can be obtained from schedules. So, scheduling is necessary for effective routing.

Thus, we can conclude that routing and scheduling are inter-related, inter-connected and inter-dependent activities of production planning and control.

Relationship between Routing and Scheduling: Both are interconnected as scheduling is difficult without routing and routing is also not effective without scheduling. Routing is a prerequisite for scheduling while time to be taken 'may form the basis of routing and that is fixed by scheduling.

Principles of Scheduling:

The principles of scheduling are:

(a) ***The principle of optimum task size:*** Scheduling tends to achieve its maximum efficiency when the task sizes are small and all tasks are of the same order of magnitude.

(b) ***The principle of the optimum Production plan:*** Scheduling tends to achieve its maximum efficiency when the work is planned, so that it imposes an equal/even load on all the plant.

(c) ***The principle of the optimum operation sequence:*** Scheduling tends to achieve its maximum efficiency when the work is planned so that the work centers are normally used in the same sequence.

The first principle has a tendency when applied, not only give good results but also to be self-correcting if it is ignored. For example, if in a functional batch production machine shop the loads imposed by different operations vary greatly in length it is possible that it will be necessary to break many of the long operations into one or more small batches, in order to get the other orders completed by due date. In effect, this principle only repeats the known advantage of maintaining a high rate of stock turn over, and of single phase ordering. The second principle merely states that the obvious fact that there will be less idle time and waiting time, if all the plant is evenly loaded by the production planners, then if some of the machines are over loaded perhaps because direct labour cost on them are lower and others are idle for part of the time due to shortage of work. The third principle says about principle of flow. Some times it is also true if we sequence some jobs, which need the same machine set up, at a time, this avoids machine ancillary time needed, in case, the jobs of the above type are done at different times. For example, consider drilling a 10 mm hole in five different jobs may be done at a time so that the set up time required for five jobs independently at different times are avoided.

Forms of Schedules:

Here we shall discuss the presentation of production schedules. Depending on the need and use, the Schedules can be prepared in different forms.

A Production Flow Program:

If a number of components or assemblies have to be manufactured for the final assembly line and those components are to be made concurrently, the production master flow program is prepared taking into account the sequence of operations and the time of starting and ending each component in order to comply with the required date of completion of the product. The necessary document for this is Operation Process Chart and the Sequence of Operation.

Scheduling Systems:

Scheduling Systems may be classified into four groups as shown below:

(i) ***Unit scheduling system:*** This is used for scheduling when jobs are produced one by and are of different a type that is for job production.

(ii) ***Batch scheduling system:*** When jobs are produced to order, in batches, this is used.

(iii) ***Mass scheduling system:*** When large number of items of similar type are produced that is in mass production, this is used.

Unit Scheduling System:

Here we have two types of scheduling, one is Project scheduling and the other is Job Scheduling.

Project Scheduling: Generally, a project consists of number of activities managed by defferent Apartments or individual supervisors. It can also be said as a complex output made up of many interdependent jobs. Examples are: Railway coach building, Shipbuilding etc. The scheduling methods used are:

(i) Project Evaluation and Review Technique (PERT),

(ii) Critical Path Method (CPM),

(iii) Graphical Evaluation and Review Technique (GERT).

We can also use Bar charts, GANTT charts, Milestone chart, but these are less superior to the above.

Job Shop Scheduling: In Job shop scheduling, we come across varieties of jobs to be processed on different types of machines. Separate records are to be maintained for each order. Only after receiving the order, one has to plan for production of the job. The routing is to be specified only after taking the order. Scheduling is done to see that the available resources are used optimally. The following are some of the methods used for scheduling. (i) Arrival pattern of the job, (ii) Processing pattern of the job, (iii) Depending on the type of machine used, (iv) Number of workers available in the shop, (v) Order of sequencing.

Arrival pattern of the job: This is done in two ways. Firstly, as and when the order is received, it is processed on the principle First in First Out (FIFO). Otherwise, if the orders are received from single customer at different point of time in a week/month, then the production manager pile up all orders and starts production depending on the delivery date and convenience (This situation is generally known as static situation).

Processing Pattern of the Job: As the layout of Job shops of Process type and there may be duplication of certain machines, the production planner, after receiving the order thinks of the various methods of converting the requirement of customer / order into a production plan to suit the available facilities. Depending on the process required, there may be backtracking, which is unavoidable. When facilities are busily engaged, in process inventory may be a common problem.

Machine varieties available: Facilities available in the production shop will affect the scheduling. Here the size, capacity, precession and other factors of machines will have their influence on the scheduling.

Number of Men in the production shop: Many a time we see that the number of workers available in the job shops are very much limited, that is sometimes they are less in number than the machines in the shop (these shops are known as labour limited shop). Depending the availability of labour, the scheduling is to be done. In case the machines available are limited and have more men (known as machine limited shops), then availability of machine dictates the scheduling.

Sequencing rules for single facility: When we have a single facility, and the orders are in queue, then they are processed depending on the rules mentioned below:

(a) ***First in first served or first in first out (FIFS/FIFO):*** Here the jobs are processed as they come in. This is commonly observed queue discipline.

(b) ***Shortest processing time (SPT):*** The jobs having shortest processing time are processed first. This is just to avoid formation of queue. For example, when you go for Xeroxing a document, and other person comes for Xeroxing a book, then document is Xeroxed and then the book is taken for Xeroxing.

(c) ***Minimum due date (MDD):*** Here jobs are processed in ascending order of their available time before delivery date. By doing so, we can keep up the delivery promises. To meet the delivery promises, if necessary, overtime, sub contracting etc., may be used.

(d) ***Last come first served or last in first out (LCFS/LIFO):*** This generally happens in case of inventory stocking and using. When material piles up, the material at the top i.e., material last arrived is used first.

(e) ***Static slack for remaining operations (SSRO):*** Static slack is given by: (Due date - Remaining processing time/number of remaining operations). Here jobs are processed in ascending order of the operations.

(f) ***Dynamic slack for remaining operations (DSRO):*** Dynamic slack is given by: (Due date - expected time of remaining operations / number of remaining operations). Here the jobs are done in ascending order of the ratio dynamic slack.

Basic Scheduling Problems:

The production planner may face certain problems while preparing production plans or Schedules. Some important problems are discussed below:

(a) Flow production scheduling for fluctuating demand (known smoothening problem),

(b) Batch production scheduling, when products are manufactured consecutively,

(c) The assignment problem,

(d) Scheduling orders with random arrivals and

(e) Product sequencing.

Problems and Solutions

Problem: 1

A company has two plants A and B with fixed costs of Rs. 50,000 and Rs. 70,000 respectively. Both the plants are designed to produce up to 10,000 units each. The variable costs of two plants at different of production are as follows:

Production (Units)	Plant A (Rs.)	Plant B (Rs.)
2,500	36,000	29,000
5,000	45,000	39,000
7,500	77,000	51,000
10,000	1,10,000	1,15,000

Find the most economic loading schedule.

Solution:

The fixed costs are irrelevant and only the incremental costs should be considered. Incremental costs will be as follows:

	Plant A (Rs.)	Plant B (Rs.)
Total incremental costs	36,000	29,000
	9,000	10,000
	32,000	12,000
	33,000	64,000
Per unit incremental costs	14.40	11.60
	3.60	4.00
	12.80	4.80
	13.20	25.60

Ans.

First	2500	Units	B
Next	2500	Units	A
Next	2500	Units	B
Next	2500	Units	A

Problem: 2

A company is setting an assembly line to produce 192 units per eight hour shift. The information regarding work elements in terms of times and immediate predecessors are given

Work element	Time (Sec)	Immediate predecessors
A	40	None
B	80	A
C	30	D, E, F
D	25	B
E	20	B
F	15	B
G	120	A
H	145	G
I	130	H
J	115	C, I
Total	720	

(i) What is the desired cycle time?

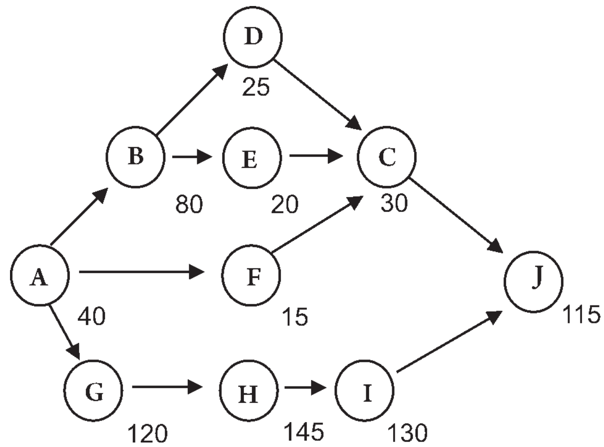
(ii) What is the theoretical number of stations?

(iii) Use largest work element time rule to workout a solution on a precedence diagram.

(iv) What are the efficiency and balance delay of the solution obtained?

Solution:

The precedence diagram is represented as shown below:



(a) Cycle time = $\frac{1}{r} = \frac{8\,\text{hours}}{192\,\text{units}}$ = 150 sec/unit, where r = output.

(b) Sum of the work elements is 720 seconds, so minimum number of work stations

$$\frac{\sum t}{\text{cycle time}} = \frac{720\,\text{second / unit}}{150\,\text{sec/ unit station}} = 4.8 = 5\ \text{stations}$$

Assignment of work elements to work stations.

Station	Elements	Work element time in sec	Cumulative time (Sec)	Idle time for station
S_1	A	40	40	
	B	80	120	05
	D	25	145	
S_2	G	120	120	
	E	20	140	10
S_3	H	145	145	
S_4	I	130	130	
	F	15	145	05
S_5	C	30	30	
	J	115	145	05

(d) Efficiency = $\frac{\sum t}{nCt} \times 100 = \frac{720}{5 \times 150} \times 100 = 96\%$

Thus, the balance delay is [100 - 96] = 4 percent only.

Problem: 3

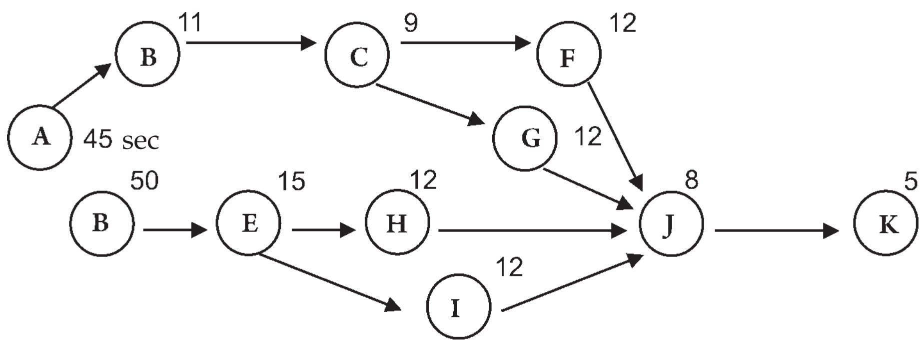
The company is engaged in the assembly of a wagon on a conveyor. 500 wagons are required per day. Production time available per day is 420 minutes. The other information is given below regarding assembly steps and precedence relationships. Find the minimum number of work stations, balance delay and line efficiency.

Solution:

The element times and precedence relationships

Task	Time (sec)	Task that must Precede
A	45	–
B	11	A
C	09	B
D	50	–
E	15	D
F	12	C
G	12	C
H	12	E
I	12	E
J	08	F, G, H, I
K	09	–
Total	195	–

(i) Precedence diagram is constructed as per the given details.



(ii) Determination of cycle time

$$C_t = \frac{\text{Production time / day}}{\text{Output / day}} = \frac{420 \times 3}{500} = \frac{25,200}{500} = 50.4$$

(iii) Theoretical number of work stations required

$$N = \frac{\text{Total time}}{\text{Cycle time}} = \frac{195}{50.4} = 3.87 \approx 4 \text{ workstations}$$

(iv) Assign the elements to work stations based on the largest element time and the work stations to be required are 5.

Balance made according to largest number of followers task rule.

Station	Task	Task time (sec)	Idle time (sec)
S_1	A	45	5.4
S_2	D	50	0.4
S_3	B	11	3.4
	E	15	
	C	09	
	F	12	
S_4	G	12	6.4
	H	12	
	I	12	
	J	8	
S_5	K	9	41.4

(iv) Efficiency = $\dfrac{T}{\text{No.of stations} \times C} = \dfrac{195}{5 \times 50.4} \times 100 = 77.38\%$

(v) Balance delay = 100 - 77.38 = 22.62%

Problem: 4

The processing times (t_j) in hrs for the five jobs of a single machine scheduling is given. Find the optimal sequence which will minimise the mean flow time and find the mean flow time.

Determine the sequence which will minimise the weighted mean flow time and also find the mean flow time

Job (j)	1	2	3	4	5
Processing time (t_j) hrs	30	8	10	28	16

Solution:

(a) First arrange the jobs as per the shortest processing time (SPT) sequence.

Job (j)	2	3	5	4	1
Processing time (t_j) hrs	8	10	16	28	30

Therefore, the job sequence that minimises the mean flow time is 2-3-5-4-1.

Computation of minimum flow time (F min)

The flow time is the amount of time the job 'f' spends in the system. It is a measure which indicates the waiting of jobs in the system. It is the difference between the completion time (C_j) and ready time (R_j) for job j.

$$F_j = C_j - R_j$$

Job (j)	2	3	5	4	1
Processing time (t_j) hrs	8	10	16	28	30
Completion time (C_j)	8	18	34	62	92

Since the ready time (R_j) = 0 for all j, the mean flow time ($\overline{F}_j$)is equal to C_j for all j. Mean flow time

$$(\overline{F}) = \frac{1}{n}\sum_{j=1}^{n} F_j = \frac{1}{5}[8+18+34+62+92] = \frac{1}{5}[214] = 42.8 \text{ hours}$$

(b) The weights are given as follows:

Job (j)	1	2	3	4	5
Processing time (t_j) hrs	30	8	10	28	16
Weight (W_j)	1	2	1	2	3

The weighted processing time = $\dfrac{\text{Processing time}(t_j)}{\text{Weight}(W_j)}$

The weighted processing time is represented as

Job (j)	1	2	3	4	5
Processing time (t_j hrs)	30	8	10	28	16
Weight (W_j)	1	2	1	2	3
t_j/W_j	30	4	10	14	5.31

Thus, arranging the jobs in the increasing order of t_j/W_j (weighted shortest processing time WSPT).

We have the optimal sequence that minimises the weighted mean flow time is 2-5-3-4 -1

flow time($\bar{F}_w$) :

$$\bar{F}_w = \frac{\sum_{j=1}^{n} w_j F_j}{\sum_{j=1}^{n} w_j}$$

Job (j)	2	5	3	4	1
Processing time (t_j) hrs	8	16	10	28	30
$F_j = (C_j - R_j)$	8	24	34	62	92
W_j	2	3	1	2	1
F_j x W_j	16	72	34	124	92

The weighted mean flow time is computed as follows for optimal sequence.

Weighted mean flow time ($\bar{F}_w$) is computed as

$$\bar{F}_w = \frac{(16+72+34+124+92)}{(2+3+1+2+1)} = 37.55 \text{ hrs.}$$

Problem: 5

The processing times and due dates of jobs for a single machine scheduling is given.

Job (j)	1	2	3	4	5	6	7
Processing time (t_j)	10	8	8	7	12	15	18
Due date (d_j)	15	10	12	11	18	25	30

Determine the sequence which will minimise the maximum lateness and also determine the maximum lateness with respect to the optimal sequence.

Solution:

Due date (d_j) is the time at which job 'j' is to be completed and Lateness (L_j) is the amount of time by which the completion time of the job j differs from the due date ($L_j = C_j - d_j$). Lateness is a measure which gives set of due dates of times. Lateness can be positive or negative. Positive lateness indicates the completion of job after its due date. It is therefore often desirable to optimize positive lateness.

Arranging the jobs as per Earliest Due Date (EDD), i.e., increasing order of their due dates. The sequence is 2-4-3-1-5-6-7. This sequence gives the minimum value of maximum lateness (L_{max})

Computation of L_{max}

Job (j) as per EDD sequence	2	4	3	1	5	6	7
Processing time (t_j)	8	7	8	10	12	15	18
Completion time (C_j)	8	15	23	33	45	60	78
Due date (d_j)	10	11	12	15	18	25	30
Lateness (L_j)	(-2)	4	11	18	27	35	48

From the above table, the maximum L_j is 48. This is the (optimised) value of L_{max}.

Problem: 6

The processing times for five jobs and their due dates are given for a single machine scheduling below.

Job (j)	1	2	3	4	5
Processing time (t_j) hrs	9	7	5	11	6
Due date (in days) (d_j)	16	20	25	15	40

(a) Determine the sequence

(b) Total completion time

(c) Average completion time

(d) Average number of jobs in the system and average job lateness using the following priority sequencing rules

  (i) Shortest Processing Time (SPT)

  (ii) Earliest Due Date (EDD)

  (iii) Longest Processing Time (LPT)

(e) Compare the above characteristics for the three sequencing rules.

Solution:

(i) Shortest Processing Time (SPT) sequence.

As per this rule, the job with the shortest processing time is scheduled first and immediately followed by next lowest processing time and so on.

Job Sequence (j)	Processing time (t_j) days	Flow time (F_j) days	Due Date (d_j) days	Job lateness (Days)
3	5	5	25	0
5	6	11	40	0
2	7	18	20	0
1	9	27	16	11
4	11	38	15	23
Total	38	99		34

The various characteristics are:

Total completion/ time (flow time)= 38 days

$$\text{Average completion time} = \frac{\text{Total flow time}}{\text{No. of jobs}} = \frac{99}{5} = 19.8 \text{ days}$$

$$\text{Average number of jobs in the system} = \frac{\text{Total flow time}}{\text{Total process time (completion)}} = \frac{99}{38} = 2.61 \text{ jobs}$$

$$\text{Average job lateness} = \frac{\text{Total Job lateness}}{\text{No. of jobs}} = \frac{34}{5} = 6.8 \text{ days}$$

(ii) Earliest Due Date(EDD) rule

As per this rule priority is given to the job with earliest due date. Arranging the jobs as per EDD sequence gives the sequence as 4-1-2-3-5.

Job sequence	Processing time	Flow time	Due Date	Job lateness
(j)	(C_j)	(F_j)	(D_j)	(Days)
4	11	11	15	0
1	9	20	16	4
2	7	27	20	7
3	5	32	25	7
5	6	38	40	0
Total	38	128		18

Characteristics:

- Total completion time = 38 days
- $\text{Average completion time} = \frac{\text{Flow time}}{\text{No. of jobs}} = \frac{128}{5} = 25.6 \text{ days}$
- $\text{Average number of jobs in the system} = \frac{\text{Flow time}}{\text{Completion time}} = \frac{128}{38} = 3.37 \text{ jobs}$
- $\text{Average job lateness} = \frac{18}{5} = 3.6 \text{ days}$

(iii) Longest Processing Time (LPT) Rule

The job sequence and computations as per this priority sequencing rule is given as follows:

Job Sequence (j)	Processing time (C_j)	Flow time (F_j)	Due Date (D_j)	Job lateness (Days)
4	11	11	15	0
1	9	20	16	4
2	7	27	20	7
5	6	33	40	0
3	5	38	25	13
Total	38	129		24

Characteristics:

- Total completion time = 38 days
- Average completion time = $\frac{\text{Flow time}}{\text{No. of jobs}} = \frac{129}{5} = 25.8\text{days}$
- Average number of jobs in the system = $\frac{\text{Flow time}}{\text{No. of jobs}} = \frac{129}{38} = 3.39$ jobs
- Average job lateness = $\frac{24}{5} = 4.8$ days

(b) Comparison of Priority rules

Priority rule	Total completion time (days)	Avg. completion time (days)	Avg. No. of jobs in the system	Avg. Job lateness
SPT	38	19.8	2.61	6.8
EDD	38	25.6	3.37	3.6
LPT	38	25.8	3.39	4.8

Problem: 7

The following jobs are waiting to be processed in a turning shop today (July, 23). The estimates of the time needed to complete the jobs are as follows:

Jobs (j)	Due date	Processing time (t_j) in days
1.	July, 31	9
2.	August, 2	6
3.	August, 16	24
4.	July, 29	5
5.	August, 30	30

Sequence the jobs based on the minimum critical ratio.

Solution:

The critical ratio is computed as

$$\text{Critical Ratio (CR)} = \frac{\text{Time needed for due date of the job}}{\text{Time needed to complete the job}} = \frac{\text{Time remaining}}{\text{Work remaining}}$$

Critical Ratio (CR) =

As per the critical ratio rule, a job with the minimum critical ratio is given the first preference, i.e., the lower is the critical ratio, higher is its priority.

The denominator of CR, i.e., the time needed to complete the job includes the processing time remaining plus the transfer times plus the estimated waiting times remaining for the job to go through before it is completely processed.

The table below gives the calculations of time remaining and time needed and the critical ratio.

Jobs (j)	Due date	Processing time (t_j) in days	Time needed to complete the job in days	Critical ratio CR = T_r/T_n
1.	July, 31	8	9	8/9 = 0.89
2.	August, 2	10	6	10/6 = 1.167
3.	August, 16	24	24	24/24 = 1.00
4.	July, 29	6	5	6/5 = 1.20
5.	August, 30	38	30	38/30 = 1.27

Note: Critical Ratio (CR) of less than one means that the job is already late.

The CR value of one indicates that the job is on schedule and greater than one indicates that the job has some slack available to it. From the table, job 1 has the lowest critical ratio and has to be processed first and job 2 has the highest critical ratio and it is scheduled last. The sequence is:

1	3	4	5	2

Problem: 8

A company has 8 large machines which receive preventive maintenance. The maintenance team is divided into 2 crews A and B. Crew A takes the machine power and replaces parts as per given maintenance schedule. The second crew resets the machine and puts back into operation.

At all times the no passing rule is considered to be in effect. The servicing time for each machine is given below.

Machine	a	b	c	d	e	f	g	h
Crew A	5	4	22	16	15	11	9	4
Crew B	6	10	12	8	20	7	2	21

Determine the optimal sequence of scheduling the factory maintenance crews to minimise their idle times and represent it on the Gantt chart.

Solution:

Step I : The minimum processing time on crew A is kept first in sequence while machine with processing times minimum on crew B is kept last in sequence.

Optimal sequence:

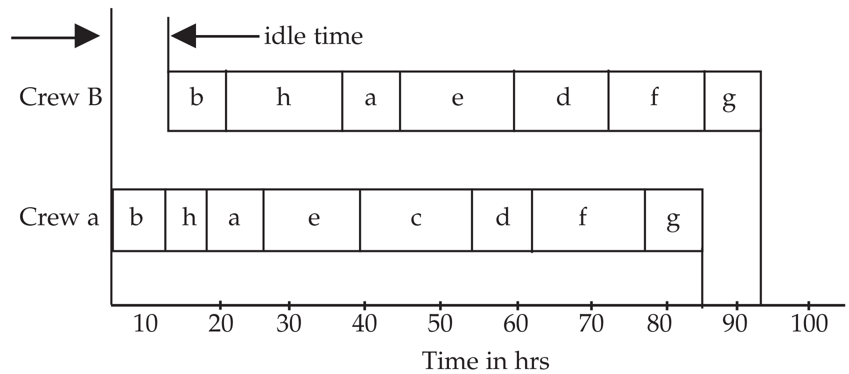
b	h	a	e	c	d	f	g

Step II: Calculation of total elapsed time

Optimal	Crew A		Crew B		Idle time on
Sequence	S	F	S	F	Crew B
b	0	4	4	4	4
h	4	8	14	35	0
a	8	13	35	41	0
e	13	28	41	61	0
c	28	50	61	73	0
d	50	66	73	81	0
f	66	77	81	88	0
g	77	86	88	90	0

Total elapsed time is 90 hrs.

Gantt Chart



Problem: 9

The following is a tentative master schedule for 4 weeks at a small company

	Week			
Product	1	2	3	4
A	2000	4000	1000	2000
B	3000	1000	4000	3000

The labour in the key work centers for the company’s two major products is as follows

Product

Dept.	A	B
4	0.21	0.07
11	0.06	0.1
14	0.11	0.08

Determine the load on department 4 over the next 4 weeks.

Solution:

Hours required in each week:

Week 1:	For product A = 0.21(2000) =	420
	For product B = 0.07(3000) =	210
	Total load for the week =	630
Week 2:		
	For product A = 0.21(4000) =	840
	For product B = 0.07(1000) =	70
	Total load for the week =	910
Week 3:		
	For product A = 0.21 (1000) =	210
	For product B = 0.07(4000) =	280
	Total load for the week =	490
Week 4:		
	For product A = 0.21(2000) =	420
	For product B = 0.07(3000) =	210
	Total load for the week	630

Note that this load profile is not very uniform, even though 5000 units of products are produced each week.

Line Balancing

Assembly line balancing is associated with a product layout in which products are processed as they pass through a line of work centres. An assembly line can be considered as a “production sequence” where parts are assembled together to form an end product. The operations are carried out at different workstations situated along the line.

The Problem of Line Balancing:

It arises due to the following factors

1. The finished product is the result of many sequential operations.
2. There is a difference in production capacities of different machines Line balancing is the apportionment of sequential work activities into workstations in order to gain a high utilisation of labour and equipment so as to minimise the idle time. For example, the production capacities of two machines A and B are as under for a particular job: A 50 pieces/hour; B 25 pieces/hour.

Now, if only one machine of each is provided, then machine B will produce 25 units/hour where as the machine A can produce 50 units. But because of the sequence, only 25 units are produced per hour, i.e., machine A will work only 50 per cent of its capacity and the remaining 30 minutes in one hour, it is idle. This idle time can be minimised by introducing one more machine of kind B in the production line.

Steps in Solving Line Balancing Problems

1. Define task.
2. Identify precedence requirements.
3. Calculate minimum number of workstations required to produce desired output.
4. Apply heuristics to assign task to each station.
5. Evaluate effectiveness and efficiency.
6. Seek further improvement.

Three important parameters in line balancing

Total station time

1. Line efficiency (LE) $= \dfrac{\text{Total station tim}}{\text{Cycle time} \times \textit{no of workstations}} \times 100$

2. Balance delay (BD) $= \dfrac{\text{Total idle time for all workstation}}{\text{Total available working time on all station}} \times 100$

   BD = (1-LE)

3. Smoothness Index (SI) = $\sum_{i=l}^{k}$ (Max. station time - station times of station i)^2

   SI = 0, means a perfect balance

   K = total number of workstations < total number of elements

   Also, CT > maximum time of any work element n

Terms used in the context of Line Balancing:

1. Workstation: A work station is a location on assembly line where given amount of work is performed.
2. Cycle time: It is the amount of time for which a unit that is assembled is available to any operator on the line or it is the time the product spends at each work station.

   Cycle Time (CT) = $\dfrac{\text{Available time period}}{\text{Output units required / period}} = \dfrac{\text{AT}}{\text{Output}}$

3. Task: The smallest grouping of work that can be assigned to a workstation.
4. Predecessor task: A task that must be performed before performing another (successor) task.
5. Task time: Standard time to perform element task.

6. Station time (sk): Total standard work content of specific workstation.
7. Balance Delay (BD): Percentage of total idle time on the line to total time spent by the product from beginning to end of line.

$$\text{B.D} = \frac{\text{n.CT} - \sum_{k=1}^{n} \text{sk} \times 100}{\text{n} \times \text{CT}}$$

B.D= Balance delay

n = number of work stations, CT = Cycle time

sk = Station time

Sequencing Model

This model is used for sequencing the jobs on the machines so as to minimize the total processing time. We have different sequencing models. They are:

(i) Sequencing 'n' jobs on 2 machines,

(ii) Sequencing 'n' jobs on 3 machines,

(iii) Sequencing 'n' jobs on 'm' machines,

(iv) Sequencing 2 jobs on 'w' machines,

(v) Sequencing of 'n' jobs on two machines.

The order in which jobs pass through machines or work-stations is a sequencing problem and analysis of this problem is sequence analysis. A production manager or a person who has been assigned the job of sequencing the manufacturing of a product must know about the necessary operations and the possible order in which these can be performed so that die idle time can be minimised. The effectiveness of sequencing may be measured by time and cost factors. Saving in time also affects the cost.

The main problem of sequencing is the assignment of various jobs to different machines. When there are very few different types of jobs or machines, the problems is not much serious and it is solved informally by sketching the flow mentally or on a time chart. Suppose, if these are two jobs and two machines (2x 2 problem), there is no problem of assignment of jobs to machines. There are two possible sequence in this case —job 1 first and job 2 second or vice versa.

It becomes more tedious as the number of jobs and machines increases. We shall discuss or analyse the following two cases:

(i) n jobs are to be processed on two machines A and B in the order AB.

(ii) n jobs are to be processed on three machines A, B and C in the order ABC.

(1) ***Assignment of jobs to two machines:*** Assuming that there are a number of jobs to be processed on two machines and the processing time for each job on each machine is known and that each job is first processed on Machine A and then on Machine B, the sequence of different jobs on machine A and B may be assigned as follows:

(i) First, we should find out the least processing time. If it is on Machine A, it should be ranked first on Machine A. If it is on Machine B, it should be placed at the last in the sequence.

(ii) The next step would be to delete the job selected in step (i) above either to Machine A or B from the list of jobs to be assigned. This process should be repeated to the remaining jobs. This process will be continued until a complete sequence of all the jobs is obtained. If two jobs have the same time on the same machine (if it is smaller than the time on the other machine), the order of assignment for these two jobs is arbitrary.

This technique applies to single unit or single type batch jobs where jobs have no priority for completion. In this technique it is also presumed that there is sufficient in-process storage space and the cost of in-process inventor is the same or varies very insignificantly for all units. These assumptions are valid only for short processes. For extended process, oilier criterion such as closer inventor, cost control or expediting priorities etc. are considered other than minimising elapsed time. Other complicating variables may be variable transportation time between machines, improving the defective work, breakdowns of machine and variable time caused by operator proficiencies or working conditions.

(2) ***Assignment of jobs to three machines:*** Assuming that there are a number of jobs to be processed on three machines A, B and C in the order of ABC, i.e., first it is processed on machine A, then on Machine B and then on machine C. The problem can be solved if either of the two conditions is satisfied.

(i) The least processing time of any job on Machine A is greater than or equal to the maximum processing time of any job on Machine B.

(ii) The smallest processing time for any job on Machine C is either equal to or greater than the processing time for any job on Machine B.

If any of the above two conditions is satisfied, the job processing times are converted into the following ways:

a. We shall add job processing times (as given) of different jobs on; Machine A and B; and

b. Again job processing time for various jobs (given) on Machine B and C shall be added.

After this process, the optional sequence can be obtained in the same way as it is assigned on two machines.

2.9 Economic Batch Production

Production managers often have to decide what quantity of output must be produced in a batch (known as lot size or batch size). The products are manufactured in lot sizes against the anticipated demand for the products. Often the quantity produced may exceed the quantity which can be sold. (i.e., production rates exceed demand rates). The optimum lot size which is known as economic lot size or economic batch quantity or economic manufacturing quantity is that quantity of output produced in one batch, which is most economical to produce, i.e., which results in lowest average cost of production.

Determination of Economic Lot Size for Manufacturing:

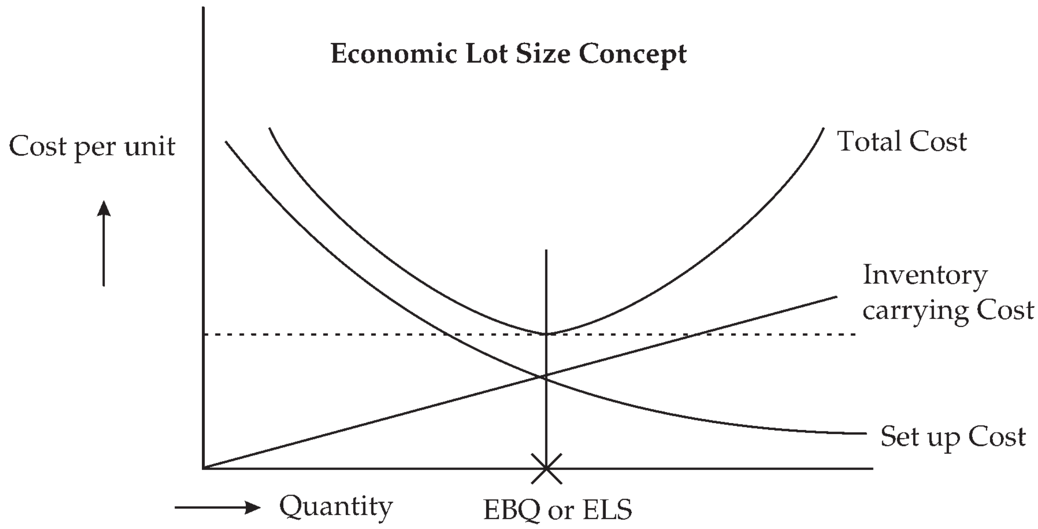
The factors to be considered in arriving at the economic lot size are:

(i) ***Usage rate:*** The rate of production of parts should match with the rate of usage of these parts in the assembly line.

(ii) ***Manufacturing cost:*** Higher the lot size, lower will be the cost per unit produced because of distribution of set up costs for setting up production or machines and preparing paper work (production orders). But the carrying cost (handling and storing costs) will increase with increase in lot size.

(iii) ***Cost of deterioration and obsolescence:*** Higher the lot size, higher will be the possibility of loss due to deterioration (items deteriorating after shelf life) or obsolescence (due to change in technology or change in product design).

Before deciding on production using economic lot sizes, the availability of production capacity to produce the product in economic lot size must be verified. The economic lot size balances the two opposing costs related to batch size i.e., setup cost for production and the inventory carrying costs resulting from inventory of products produced when production rate exceeds usage rate or when the items produced are not immediately consumed in the next stage of production. The set up cost per unit decreases with increase in lot size whereas the inventory carrying cost increases with increase in lot size. Diagram below illustrates the concept of economic batch quantity or economic lot size.



EBQ = Economic Batch Quality
ELS = Economic Lot Size

If S is the set up cost per set up, 'C' is the production cost per unit produced and I is the inventory carrying changes (%) and A is the annual demand for the item in units, then,

Economic Batch Quantity (EBQ)

or Economic Lot Size (ELS)

or Economic Manufacturing Quantity (EMQ)

$$= \sqrt{\frac{2AC}{CI}} = \sqrt{\frac{2 \times \begin{pmatrix}\text{Annual demand}\\ \text{(in units)}\end{pmatrix} \times \begin{pmatrix}\text{Set up Cost}\\ \text{per set up}\end{pmatrix}}{\begin{pmatrix}\text{Production Cost}\\ \text{per unit}\end{pmatrix} \times \begin{pmatrix}\text{Inventory conveying}\\ \text{charges (percentage)}\end{pmatrix}}}$$

Economic Run Length: When a firm is producing an item and keeping it in inventory for later use, instead of buying it, the formula used to calculate economic order quantity (EOQ) can be used to calculate the economic production quantity referred to as Economic Run Length (ERL).

If 'p' is the production rate and 'd' is the demand rate (or consumption rate), A is the annual demand for the item in units, I is the inventory carrying charges (percentage), C is the production cost per unit, then,

$$\text{Economic Run Length (ERL)} = \sqrt{\frac{2AS}{CI\left(1-\frac{d}{p}\right)}}$$

$$= \sqrt{\frac{2\times\begin{pmatrix}\text{Annual demand}\\ \text{(in units)}\end{pmatrix}\times\begin{pmatrix}\text{Set up Cost}\\ \text{per set up}\end{pmatrix}}{\begin{pmatrix}\text{Production cost}\\ \text{per unit}\end{pmatrix}\times\begin{pmatrix}\text{Inventory conveying}\\ \text{charges (percentage)}\end{pmatrix}-\left(\frac{\text{Demand Rate}}{\text{Production Rate}}\right)}}$$

Problems and Solutions

Problem: 1

C Ltd. produces a product which has a monthly demand of 4,000 units. The product requires a component *X* which is purchased at Rs. 20. For every finished product, one unit of component is required. The ordering cost is Rs. 120 per order and the holding cost is 10% p.a.

You are required to calculate:

(i) Economic order quantity.

(ii) If the minimum lot size to be supplied is 4,000 units, what is the extra cost the company has to incur?

(iii) What is the minimum carrying cost, the company has to incur.

Solution:

(i) Economic Order Quantity:

Annual consumption of component X (C_0):

4,000 units per month for 12 months = 48,000 units;

Ordering cost per order (O) = Rs. 120 and Carrying cost (i.e., holding cost) of one unit of component for one year (C_c) = 10% of Rs. 20 = Rs. 2

$$EOQ = \sqrt{\frac{2C_oO}{C_o}} = \sqrt{\frac{2\times 48,000\text{ units}\times \text{Rs.}120}{\text{Rs.}2}} = 2,400\text{ units}$$

(ii) Extra cost to be incurred by the company:

Cost when order size is 4,000 units $\left(\text{i.e.,} \dfrac{48,000}{4,000} \text{or 12 orders p.a.}\right)$

	Rs.
Ordering cost : 12 order p.a. at Rs. 120 per order	1,440
Carrying cost of average inventory :	
$\dfrac{4,000\,\text{units}}{2} \times \text{Rs.}\,2$	4,000
Total annual cost	5,440

cost when order size is 2,400 units (i.e, $\dfrac{48,000}{2,400}$ or 20 orders p.a.)

	Rs.
Ordering costs : 20 orders p.a. at Rs.. 120 per order	2,400
Carrying cost of average inventory:	2,400
Total annual cost	4,800

Extra cost to be incurred : Rs. (5,440 - 4,800) = Rs. 640.

(iii) Minimum carrying cost to be incurred by the company:

Since carrying cost depends upon the size of the order, carrying cost will be the minimum at the economic order quantity. Hence the minimum carrying cost is Rs. 2,400 as calculated in (ii) above.

Problem: 2

M/s Kobo Bearings Ltd., is committed to supply 24,000 bearings per annum to M/s Deluxe Fans on a steady daily basis. It is estimated that it costs 10 paisa as inventory holding cost per bearing per month and that the setup cost per run of bearing manufacture is Rs. 324.

(a) What is the optimum run size for bearing manufacture? (b) What should be the interval between the consecutive optimum runs? (c) Find out the minimum inventory holding cost.

Solution:

(a) Optimum run size or Economic Batch Quantity (EBQ)

$$= \sqrt{\frac{2 \times Annual\,Output \times Setup\,cost}{Annual\,Cost\,of\,Carrying\,one\,unit}} = \sqrt{\frac{2 \times 24000 \times 324}{0.10 \times 12}} = 3600\,\text{units}$$

(b) Interval between two consecutive optimum runs = $\dfrac{EBQ}{Monthly\ Output} \times 30$

$$= \frac{3600}{24000 \div 12} \times 30 = 54 \text{ Calendar days}$$

(c) Minimum inventory holding cost = Average inventory × Annual carry-ing cost of one unit of inventory

= (3600÷2) ×0.10×12 = Rs. 2,160.

Problem :3

The demand of a certain item is random. It has been estimated that the monthly demand of the item has a normal distribution with a mean of 680 and a standard deviation of 130 units. The unit price of the item is Rs. 10 per unit; the ordering cost is Rs. 20. The inventory carrying cost is estimated to be 25 per cent per year respectively. The procurement lead time is constant and is one week. Find the most economic ordering policy and the expected total cost of controlling inventory, given that the service level is 97.5%.

Solution:

Under the given circumstances, Economic Order Policy involves deter-mination of EOQ, ROL and Safety Stock for a year.

EOQ = $\sqrt{\frac{2\times680\times12\times2}{0.25\times10}}$ = 361 (appx.) units; ROL = Consumption during lead time + Safety stock

= 680 ÷ 4 + ZLT. Z for 97.5% service level may be taken as 2 (1.96 from Table)

LT = S.D. during lead time = $\sqrt{Varience\ During\ Lead\ time}$ = $\sqrt{\frac{16900}{4}}$ = 130/2 = 65 units

Safety stock = 2 × 65 = 130 units; ROL = 680/4 + 130 = 300 units

Expected total cost of inventory per annum: Procurement cost = Rs. 10 × 680 × 12 = Rs. 81,600

Ordering cost = (Annual Demand / EOQ) × (Ordering cost / Order) = (680 × 12 × 20)/361.

= Rs. 452 (apx.)

Inventory carrying cost = Average inventory × inventory carrying cost = (EOQ/2 + Safety stock) × 0.25 × Rs. 10 = (361/2 + 130) × 0.25 × Rs. 10 = Rs. 776 (apx.) Total variable cost = Rs. 452 + Rs. 776 = Rs. 1,228 .

Problem: 4

A manufacturer requires 10,00,000 components for use during the next year which is assumed to consist of 250 working days. The cost of storing one component for one year is Rs. 4 and the cost of placing order is Rs. 32.

There must always be a safety stock equal to two working days usage and the lead time from the supplier, which has been guaranteed, will be five working days throughout the year. Assuming that usage takes place steadily throughout the working days, delivery takes place at the end of the day and orders are placed at the end of working day, you are required to(a) Calculate the EOQ (b) Calculate the Re-order point.

Solution:

We are given that :- D = 10,00,000 ; S = Rs. 32; C = Rs.4

$$EOQ = \sqrt{\frac{2DS}{C}} = \sqrt{\frac{2(10,00,000)32}{4}} = 4000 \text{ units.}$$

(b) Re-order point is to be calculated by the following formula;

Re-order point = Safety stock + (Average usage × Lead time)

Safety stock = (10,00,000 / 250days) = 4,000 usage per day × 2 = 8,000.

Reordering point = 8000 + (4000 units per day × Number of days)

= 8000 + (4000 ×5) = 28,000 units.

Problem: 5

The monthly requirement of raw material for a company is 3000 units. The carrying cost is estimated to be 20% of the purchase price per unit, in addition to Rs. 2 per unit. The purchase price of raw material is Rs. 20 per unit. The ordering cost is Rs. 25 per order. (i) You are required to find EOQ.(ii) What is the total cost when the company gets a concession of 5% on the purchase price if it orders 3000 units or more but less than 6000 units per month. (iii) What happens when the company gets a concession of 10% on the purchase price when it orders 6,000 units or more? (iv) Which of the above three ways of orders the company should adopt?

Solution:

We are given that,

D = 3,000 × 12 = 36,000 units per annum ; S = Rs. 25;

C = 2 + 20% of Rs. 20 = 2 + 4 = Rs. 6

$$\text{(i) } EOQ = \sqrt{\frac{2DS}{C}} = \sqrt{\frac{2 \times 36000 \times 25}{6}} = \sqrt{300,000} = 548 \text{ units (approx.)}$$

Total cost= Ordering Cost + Cost of raw material + Storage cost

= (36,000 / 548) × 25 + (36,000 × 20)+(548/2) ×6

= Rs. 1642.33 + 7,20,000+ 1,644 = Rs. 7,23,286.

(ii) When the company has an option to order between 3000 and 6000 units, the EOQ should be calculated with a reduction in price by 5% (due to concession); The purchase price = 95% of Rs. 20 = Rs. 19.

D = 36,000 units per annum; S = Rs. 25; C = 2 + 20% of 19 = 2 + 3.80 = Rs 5.80

$$EOQ = \sqrt{\frac{2 \times 36000 \times 25}{5.80}} = \sqrt{\frac{18,00,000}{5.80}} = 557 \text{ units app.}$$

Total cost = (36,000/557)× 25+(36,000 × 19)+ (557/2) ×5.80

= Rs. (1,615.79 + 6,84,000+1,615.30) = Rs. 6,87,231.09

(iii) When the company orders more than 6,000 units purchase price = 90% of Rs. 20 (because 10% concession)

= Rs. 18; D = 36,000 units per annum; S = Rs. 25; C = 2 + 20% of Rs. 18

= 2 + 3.60 = 5.60

$$\text{EOQ} = \sqrt{\frac{2DS}{C}} = \sqrt{\frac{2 \times 36000 \times 25}{5.60}}$$ = 567 units app. Total cost

= (36,000/567) ×25+ (36,000×18)+ (567/2) ×5.60

= Rs. 1,587.30 + 6,48,000 + 1,587.60 = Rs. 6,51,174.90

(iv) Comparing these costs, we notice that the cost is minimum for (iii) order. Therefore the company should adopt a policy of ordering 567 units per order.

Problem: 6

M/s. Tubes Ltd. are the manufacturers of picture tubes of T.V. The following are the details of their operation during 2001:

Average monthly market demand	2,000 tubes
Ordering cost	Rs. 100 per order
Inventory carrying cost	20% per annum
Cost of tubes	Rs. 500 per tube
Normal usage	100 tubes per week
Minimum usage	50 tubes per week
Maximum usage	200 tubes per week
Lead time to supply	6 – 8 weeks

Compute from the above:

(1) Economic order quantity. If the supplier is willing to supply quarterly 1,500 units at a discount of 5%, is it worth accepting?

(2) Maximum level of stock.

(3) Minimum level of stock.

(4) Re-order level of stock.

Solution:

(1) Economic Order Quantity:

Annual usage of tubes (C_o) = Normal usage per week × 52 weeks

= 100 tubes × 52 weeks

= 5,200 tubes.

Ordering cost per order (O) = Rs. 100.

Inventory carrying cost per unit per annum = 20% of Rs. 500 = Rs. 100.

$$EOQ = \sqrt{\frac{C_o O}{C_o}} = \sqrt{\frac{2 \times 5,200 \text{ units} \times \text{Rs.}100}{\text{Rs.}100}} = 102 \text{ units (approx.)}.$$

Evaluation of order size of 1,500 units at 5% discount

No. of orders $= \frac{5,200 \text{ units}}{1,500 \text{ units}}$ = 3.46 units or 4 (in case of a fraction, the next whole number is considered).

	Rs.
Ordering cost order per year at Rs. 100 per order	400
Carrying cost of average inventory:	
$\frac{1,500 \text{ units}}{2} \times \text{Rs.}(500 \text{ less } 5\%) \times \frac{20}{100}$	71,250
Total annual cost (excluding item cost)	71,650
Annual cost if EO Q (102 units) is adopted :	Rs.
Ordering cost: 5,200 ÷ 102 or 51 orders per year of Rs. .100 per order	5,100
Carrying cost of average inventory $\frac{102 \text{ units}}{2} \times \text{Rs.} 500 \times \frac{20}{100}$	5,100
Total annual cost (excluding item cost)	10,200

Increase in annual cost: Rs. (71,650 – 10,200) = Rs. 61,450.

Amount of quantity discount: 5% × Rs. 500 × 5,200, units = Rs. 1,30,000.

Since the amount of quantity discount (Rs. 1,30,000) is more than the increase in total annual cost (Rs. 61,450), it is advisable to accept the offer. This will result in a saving of Rs. (1,30,000 - 61,450) or Rs. 68,550 p.a. in inventory cost.

(2) Maximum Level of Stock:

= Re-order level + Re-order quantity – (Minimum usage × Minimum delivery period)

= 1,600 units + 102 units – (50 units × 6 weeks) = 1,402 units.

(3) Minimum Level of Stock:

= Re-order level – (Normal usage × Normal delivery period) [see Note]

= 1,600 units – (100 units × 7 weeks) = 900 units.

Note: Normal delivery period is taken to be the average delivery period.

(4) Re-order Level of Stock:

= Maximum usage × Maximum delivery period = 200 units × 8 weeks = 1,600 units.

2.10 Human Resource Planning

HRP is a process of stricking balance between human resources required and acquired in an organisation. In other words, HRP is a process by which an organisation determines how it should acquire its desired manpower to achieve the organisational goals. Thus, HRP helps an organisation have the right number and kind of people at the right places and right times to successfully achieve its overall objectives. Human resource planning is a process of determining and assuming that the organisation will have an adequate number of qualified persons, available at the proper times, performing jobs which meet the needs of enterprise and which provide satisfaction for the individuals involved.

HRP is the process- including forecasting, developing and controlling-by which a firm ensures that it has the right number of people and the right kind of people at the right places at the right time doing work for which they are economically most useful.

HRP can be defined as the comparisons of an organisation's existing labour resources with forecast labour demand, and hence the scheduling of activities for acquiring, training, redeploying and possibly discarding labour. It seeks to ensure that an adequate supply of labour is available precisely when required.

HRP could be seen as a process, consisting of the following series of activities:

1. Forecasting future personnel requirements, either in terms of mathematical projections of trends in the economy and developments in the industry, or of judgements estimates based upon specific future plans of the company.
2. Inventing present manpower resources and analysing the degree to which these re-sources are employed optimally.
3. Anticipating Manpower Problems by projecting present resources into the future and comparing them with the forecast of requirements, to determine their adequacy, both quantitatively and qualitatively.
4. Planning the necessary programmes of recruitment, selection, training, employment, Utilisation, transfer, promotion, development, motivation and compensation so that future man power requirements will be duly met.

Objectives of HRP :

The main objective of having human resource planning is to have an accurate number of employees required, with matching skill requirements to accomplish organisational goals. In other words, the objectives of human resource planning are to:

- Anticipate the impact of technology on jobs and requirements for human resources.
- Assess surplus or shortage, if any, of human resources available over a specified period of time.
- Control the human resources already deployed in the organisation.
- Ensure adequate supply of manpower as and when required.
- Ensure proper use of existing human resources in the organisation.
- Forecast future requirements of human resources with different levels of skills.
- Provide lead time available to select and train the required additional human resource over a specified time period.

Importance of HRP:

1. Despite growing unemployment, there has been shortage of human resources with required skills, qualification and capabilities to carry on works. Hence the need for human resource planning.
2. Human resource planning is also essential in the face of marked rise in workforce turnover which is unavoidable and even beneficial. Voluntary quits, discharges, marriages, promotions and seasonal fluctuations in business are the examples of factors leading to workforce turnover in organisations. These cause a constant change and flow in the work force in many organisations.
3. Human resource planning is also needed in order to meet the needs of expansion and diversification programmes of an organisation.
4. Large numbers of employees, who retire, die, leave organisations, or become incapacitated because of physical or mental ailments, need to be replaced by the new employees. Human resource planning ensures smooth supply of workers without interruption.
5. Technological changes and globalisation usher in change in the method of products and distribution of production and services and in management techniques. These changes may also require a change in the skills of employees, as well as change in the number of employees required. It is human resource planning that enables organisations to cope with such changes.
6. The need for human resource planning is also felt in order to identify areas of surplus personnel or areas in which there is shortage of personnel. Then, in case of surplus personnel, it can be redeployed in other areas of organisation. Conversely, in case of shortage of personnel, it can be made good by downsizing the work force.

Human resource planning is important to organisation because it benefits the organisation in several ways. The important ones are mentioned below:

1. By maintaining a balance between demand for and supply of human resources, human resource planning makes optimum use of human resources, on the one hand, and reduces labour cost substantially, on the other.
2. Careful consideration of likely future events, through human resource planning might lead to the discovery of better means for managing human resources. Thus, foreseeable pitfalls might be avoided.
3. Human resource planning compels management to assess critically the strength and weaknesses of its employees and personnel policies on continuous basis and, in turn, take corrective measures to improve the situation.
4. Human resource planning helps the organisation create and develop training and succes-sion planning for employees and managers. Thus, it provides enough lead time for internal succession of employees to higher positions through promotions.
5. Human resource planning meets the organisation need for right type of people in right number at right times.
6. It also provides multiple gains to the employees by way of promotions, increase in emolu-ments and other perquisites and fringe benefits.
7. Last but no means the least, with increase in skill, knowledge, potentialities, productivity and job satisfaction, organisation becomes the main beneficiary. Organisation is benefited in terms of increase in prosperity / production, growth, development, profit and, thus, an edge over its competitors in the market.

8. Manpower shortfalls and surpluses may be avoided, to a large extent.
9. Some of the problems of managing change may be foreseen and their consequences mitigated. Consultations with affected groups and individuals can take place at an early stage in the change process. This may avoid resistance for change.
10. Through human resource planning, duplication of efforts and conflict among efforts can be avoided, on the one hand, and coordination of worker's efforts can be improved, on the other.

Forecast requirement for human resources in the future:

There are various techniques varying from simple to sophisticated ones employed in human resource forecasting. These include:

1. Management Judgement,
2. Work-Study Method,
3. Ratio-Trend Analysis,
4. Delphi Technique,
5. Flow Models,
6. Mathematical Models.

2.11 Material Requirement Planning

Material requirement planning (MRP) refers to the basic calculations used to determine component requirements from end item requirements. It also refers to a broader information system that uses the dependence relationship to plan and control manufacturing operations.

MRP is a technique of working backward from the scheduled quantities and needs dates for end items specified in a master production schedule to determine the requirements for components needed to meet the master production schedule. The technique determines what components are needed, how many are needed, when they are needed and when they should be ordered so that they are likely to be available as needed. The MRP logic serves as the key component in an information system for planning and controlling production operations and purchasing. The information provided by MRP is highly useful in scheduling because it indicates the relative priorities of shop orders and purchase orders.

"Materials Requirement Planning (MRP) is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy master production schedule requirements."

MRP is one of the powerful tools that, when applied properly, helps the managers in achieving effective manufacturing control.

MRP Objectives:

1. ***Inventory reduction:*** MRP determines how many components are required, when they are required in order to meet the master schedule. It helps to procure the materials/components as and when needed and thus avoid excessive build up of inventory.
2. ***Reduction in the manufacturing and delivery lead times:*** MRP identifies materials and component quantities, timings when they are needed, availabilities and procurements and actions required to

meet delivery deadlines. MRP helps to avoid delays in production and priorities production activities by putting due dates on customer job orders.

3. ***Realistic delivery commitments:*** By using MRP, production can give marketing timely information about likely delivery times to prospective customers.

4. ***Increased efficiency:*** MRP provides a close coordination among various work centres and hence helps to achieve uninterrupted flow of materials through the production line. This increases the efficiency of production system.

Functions served by MRP

1. **Order planning and control:** When to release orders and for what quantities of materials.

2. **Priority planning and control:** How the expected date of availability is compared to the need date for each component.

3. Provision of a basis for planning capacity requirements and developing a broad business plans.

2.12 Productivity Measurement Techniques of Factors of Production

Productivity implies development of an attitude of mind and a constant urge to find better, cheaper, quicker, easier and safe ways of doing a job manufacturing an article and providing a service. Since the beginning of the industrial era, the manufacturers or producers have been facing the problem of how to use the available resources and factors of production to the best of their ability and capacity so as to get the maximum output with the minimum cost of production. Industrial revolution, social, technological and scientific developments, changes in economic systems is the various efforts made in this direction and the process of development and changes is still on. New and new machines, methods and technology are being invented and used in the industrial field to minimise the wastage of men, materials and machines. It is all to increase the productivity.

Productivity is the quality or state of being productive. It is some relationship of outputs to inputs. It is a concept that guides the management of a production system, and measures its success. It is the quality that indicates how well labour, capital, materials and energy are utilised. Productivity improvement is sought everywhere because it supports a higher standard of living, helps control inflation, and contributes towards a stronger national economy.

Productivity is an indicator reflecting the changes in the performance of the enterprise and having some sort of input-output comparisons relating to various activities of an organisation. It also facilitates the management to control and plan its future operations of the enterprise.

Productivity is the talk of the day and it is generally regarded as efficiency in industrial production to be measured by some relationship between outputs and inputs. The increase in productivity is looked upon as the key to prosperity at all levels. In its modern sense, it refers to the relationship between the result and the means employed or to be more specific between the product and the factors used for obtaining it. It is the quantitative relationship between what we produce and (the resources which we use to obtain it. It can also be termed as the ratio of what is produced to what is required to produce it. The higher is the ratio, the greater is the productivity. Thus, it seeks to measure the economic soundness of the use of the means. It means productivity can be considered higher if the same amount of production is obtained with lesser means or it will be lower if the same quantity of produce is obtained with larger quantity of means. It is higher when there is maximum production with the least expense of resources.

A productivity index is a device of expressing the ratio between outputs and the inputs of the resources numerically. These indices are prepared by comparing the volume of output of goods with the labour employed on that job or the profits of the firm with the capital employed. If the comparison shows an upward trend in indices, it is a sign of improved or better productivity or vice-versa.

The productivity is a measure of how much input is required to achieve a given output.

Symbolically:

$$P = \frac{O}{I} \quad \text{where} \quad P = \text{Productivity;}$$

$$O = \text{Output,}$$

$$I = \text{Input.}$$

The output may be measured in terms of the units of goods produced or the value of goods and services produced. The input, on the other hand, can be referred to as the combination of different factors, i.e., raw materials, machinery, worker's time, power, efforts and imagination of entrepreneur and the managers. A unit of input, therefore, can be expressed as one worker, or one hour of labour time or one tonne of raw materials, or one kw of electricity and so on. Thus, it is very clear from the above description that the productivity can be calculated or measured for each one of the factors comprising the input or of all the factors together. The productivity of labour, for example, can be found out by ascertaining the ratio between the quantity of goods produced and the number of workers or man-hours employed on the production of such output.

The importance of the concept of productivity can be viewed from the following points:

1. ***To beat the competition***: It is an age of cut-throat competition. There may be other commodities which can serve as the substitutes of the terms 'product' and can attract the consumers' purchasing power. The firm whose productivity is higher can only beat the competition and can exist in the market for long.

2. ***Guide to Management***: The productivity indices are very useful for the management and can be used for different purposes. These indices can serve as a valuable guide to the management for improving the performance of its enterprise. The productivity measures can be used for the following purposes:

   (a) ***Strategic :*** With the help of productivity indices, the efficiency of different firms can be measured, analysed and compared. The necessary steps can be taken to improve the productiveness of the firm taking in view the productiveness of the other competitive firms.

   (b) ***Tactical:*** Different units or the sectors of the firm can also be compared as regards to their productivity and the productivity of the less productive units or sectors can be improved.

   (c) ***Planning:*** A firm uses different inputs in producing the goods. A comparison of relative benefits accruing from the use of different inputs can be had and the most beneficial input can be used in production. It helps the management to plan for the future.

   (d) ***Administration:*** Productivity indices indicate the progress of the firm over a period of years. The productivity of different inputs, including labour, can be measured individually. The individual productivity indices help the management in bargaining with the labour leaders, trade unions and the Government in case of labour disputes regarding welfare activities. Thus administration can be improved with the help of productivity indices.

3. ***An Indicator of Progress:*** In economically backward countries, productivity movement is basic aspect of progress. It implies the development of an attitude of mind and a constant urge to better, cheaper, quicker and safer ways of doing a job, manufacturing a product and providing a service. In an urge to improve the productivity, new inventions take place. This productivity is an aspect of basic progress.

4. ***Maximum utilisation of Scarce Resources***: In order to provide the articles or commodities to the consumers at the lowest possible cost, the productivity urges to utilise the available resources to the maximum to the satisfaction of customers. The productivity processes and techniques are designed to facilitate more efficient work involving less fatigue to workers by improvements in the layout of the plant and work, better working environment and simplification of works.

5. ***Key to National Prosperity:*** The productivity, in fact, has become the synonymous to progress. Higher productivity is an index of more production with the same inputs at lower cost. It enables industry to offer goods to the general public at cheaper rates and results in expansion of markets. The working conditions and wages of workers will improve and industrialists too will get larger profits. Thus higher productivity is the key to national prosperity. The secrets of Japan and Western countries' prosperity lie in increased productivity.

6. ***Prosperity to Labour:*** The higher productivity is a boon to labour also. It brings improved working conditions, better wages and salaries to workers, better labour welfare activities to labourers. Thus their standard of living is improved.

7. **Other Uses:**

   (i) Higher productivity increases the profits and reserve funds of the industry that can be used for expansion and modernisation.

   (ii) It increases the goodwill of the firm due to cheaper goods to the public, well-off staff and more profits and better financial position.

   (iii) It improves the competitive strength of the company in export markets through reduction in cost of production and quality products.

In this way, productivity is the only way to make the overall progress of the country.

Measurement of Productivity: The productivity or the performance of various input and output factors can be measured in many ways. These measures are mainly based on the following two criteria:

(i) ***Change in output per unit of input:*** indicates the change in the performance of corresponding input during the given period, e.g., change in output per worker or per man-hour will signify the change in performance of labour.

(ii) ***Change m input per unit of output***: during the given period signifies the change in the performance of the corresponding input factor, e.g., change in man-hour or workers' per unit of output will also indicate the change in the performance of the labour input.

Productivity measurement implies the use of standards set for each input factor in terms of output. In circumstances where standards are not in use, productivity can be measured only when the output is converted into 'units or work' which is defined as the amount of work that can be performed by one unit of input. Thus productivity can be measured by dividing the output by the performance of each input factor taken together.

Some of the well-known indices of productivity are given below:

(A) ***Man-hour output***: The most widely used index of productivity is to work out the output per man-hour it can be put as –

Productivity = Units of output / Total man-hours

(B) ***Productivity Ratio*** : The rate of return on capital employed is a valuable and widely used guide to many types of business decisions. This ratio of profit to capital employed is a valuable means of measuring the performance of divisions, sections, plants, products and other components of a business, and can be calculated as—

Productivity = Net Profit / Capital employed

(C) ***Use of Financial Ratios:*** There are many situations when time standards cannot be set and therefore, it is very difficult in such cases to measure the productivity by a direct method. In these cases, financial ratios can be used to measure the productivity by using its sales turn-over. But 'added value' is a more useful approach for measuring productivity. 'Added value' means output - inputs.

The most common financial ratio of productivity is—

Productivity = Added Value / Labour Costs

Productivity = Added Value / Conversion Costs

The first ratio gives the financial productivity of labour force and the second ratio gives the financial productivity of all the resources of the company put together.

(D) ***Other Useful Measures:*** There are many other useful productivity ratios to measure the productivity of various input factors. These are:

(i) Manpower Productivity $= \dfrac{\text{Value of output of goods or services}}{\text{No. of workers or man hours used}}$

(ii) Materials Productivity $= \dfrac{\text{Value of output of goods or services}}{\text{Units (or cost) of materials used}}$

(iii) Capital Productivity $= \dfrac{\text{Value of output of goods or services}}{\text{Capital assets employed}}$

(iv) Energy Productivity $= \dfrac{\text{Value of output of goods or services}}{\text{Unit (or cost) of energy used}}$

A combined measure of productivity can be taken as

$$\text{Productivity} = \frac{\text{Value of output of goods or services}}{\text{Values of (labour + capital + materials + other inputs)}}$$

There may be other input factors such as insurance, taxes, advertising etc. and their productivity can be measured likewise.

Each measure requires different kinds of data and only rarely such information is available for all commodities in an industry on continuous basis.

Tools of productivity or how to increase productivity:

The productivity of an enterprise can be improved by improving the performance of various inputs and other factors affecting productivity. For this purpose, use of following tools can be recommended.

1. ***Human Aspects***: Under this, cooperation of workers is sought in the following ways:

(i) More workers' participation in management or in decision making through joint consultation.

(ii) Improving communication services.

(iii) Improving mutual trust and cooperation through improved job procedures, better training of employees, more workers incentives by implementing various incentive schemes, and labour welfare programmes.

(iv) Better planning of work, more effective management, more democracy in administration, improved human relations and selection and training of personnel at various levels of management are some human efforts from the side of management in order to improve the productivity.

2. Supply of Inputs:

(i) Improvement in the nature and quality of raw materials and their supplies to the work.

(ii) Proper provision of plant, equipment and their maintenance.

(iii) Introduction of more and more machines and equipment in place of physical work.

(iv) Fuller utilisation of manpower and efficiency or capacity of plant and equipment employed.

3. Technological Aspects:

Certain methodological and technological developments are also necessary to improve the productivity of the concern.

These are;

(i) Work, time and motion studies to determine better ways and means of doing a job.

(ii) Implementing various simplification, specialisation and standardisation programmes.

(iii) Applying control techniques comprising production and planning control, cost control and quality control techniques.

(iv) Improving layout of plants, shops and machine tools, and material handling and internal transportation system.

(v) Improving inspection techniques so as to minimise the wastage and defective work.

Factors affecting industrial productivity:

Productivity is defined to be some ratio between output and input. Thus all factors which affect output and inputs will also affect the measure of productivity.

The following factors affect the productivity.

1. ***Technological Development*:** Technical factors including the degree of mechanisation, technical know-how, raw materials, layout and the methods and techniques of work determine the level of technological development in any industry. The principal factors in technological development affecting productivity are:

    (a) ***The Size of the Plant***: The size of the plant and the capacity utilisation has direct bearing on productivity. Production below or above the optimum level will be uneconomical and will tend towards lower level of productivity.

    (b) ***Research and Development***: Investment in research and development may yield better method of work and better design and quality of products.

    (c) ***Plant and Job Layout***: The arrangement of machines and positions in the plant and the set-up of the work-bench of an individual worker will determine, how economically and efficiently production will be carried out.

    (d) ***Machine and Equipment Design***: Whether the design of machinery and equipment is modern and in keeping with the limitations and capacities of the workers will also determine the production efficiency and level of productivity.

    (e) ***Production Processes***: Advanced production processes involving the use of modern integrated and automatic machinery and semi-processed materials have been known to help in raising levels of productivity.

    (f) ***Power, Raw Materials etc.*** Improved quality of raw materials and increased use of power have a favourable effect on productivity.

    (g) ***Scientific Management Techniques***: Scientific management techniques such as better planning of work, simplification of methods, time and motion study, emphasis for reduced wastage and spoilage have positive effects on productivity.

    It will be realised that technological development requires a great amount of funds and general economic and technical environment in the country. Thus capital plays an important role in increasing the productivity through implementing technological development. It should also be recognised that such developments influence the job performance of employees. With better machines, tools and processes, it should be considered that both ability and willingness to work should be increased.

2. ***Individual Factors***: Individual factors such as knowledge, skill and attitude also affect the productivity of industry. Knowledge is acquired through training, education and interest on the part of learner. Skill is affected by aptitude (one's capacity to learn a particular kind of work), personality (emotional maturity, balance of mind etc.) as also by education, experience, training etc. Increased knowledge, skill and aptitude certainly increased the productivity and a person deficient in these personal attributes is less productive than an average man.

    The attitude (willingness of employee to work for organisation) of employees towards the work and the organisation affect their productivity to a great extent. Knowledge and skill without willingness are futile. The urge to work is a complex phenomenon governed by several factors such as formal and informal organisation, leadership, need, satisfaction, influence of trade unions etc. These factors motivate the workers to work better and with enthusiasm.

3. ***Organisation Factors***: Organsiation factors include various steps taken by the organisation towards maintaining better industrial relations such as delegation and decentralisation of authority, participative management (workers' participation in management), organisational efficiency, proper, personnel policies relating to selection, placement, promotion, wage salary levels, incentives, merit rating, job evaluation, training and provision for two-way communication, supervision, etc. These factors also influence motivation. Likewise the existence of groups with higher productivity as their goal is likely to contribute to the organisational objectives. These facts were brought out by Hawthorne experiments in U.S.A. A properly-motivated worker will certainly contribute to the industrial productivity.

4. ***Work Environment***: The importance of proper work environment and physical conditions on the job has been emphasised by industrial psychologists and human engineers. Better work environment ensures the greatest ease at work through better ventilation and light arrangement, improved safety devices, reduction in noise, introducing suitable rest-pause etc.

5. ***Other factors***: There are several other factors that affect productivity. These are:

   (a) ***Natural Factors***: Physical, geographical and climatic conditions influence the productivity at large. Abundance of natural resources affects the productivity and similarly climate affects the efficiency of workers to a great extent.

   (b) ***Managerial Factors***: The industrial productivity is influenced very much through managerial ability and leadership. The managerial ability of utilising the available resources to the maximum, organising capacity, foresightedness, decision-making ability and entrepreneurship are certain factors that contribute to productivity.

   (c) ***Government Policy***: Government policies towards industry also contribute to industrial productivity. Taxation policy, financial and administrative policy, tariff policy and protection policy affect the productivity to a large extent.

   Thus, the above factors are responsible for the increased productivity.

Production and Productivity:

Production and productivity are not synonymous. Production refers to the volume, value or quantity of goods and services produced during a given period by a worker, plant, firm or economy. It is the sum total of results achieved by the various factors used together. Productivity, on the other hand, is not concerned with the volume of production. It is the ratio of output and input factors of an enterprise. It shows the efficiency of production or the efficiency level of input factors. In other words, productivity is relative to the resources used in turning out a certain amount of physical output, while production is used, more or less, in absolute sense. The distinction between (lie two terms becomes more clear when we find that increase in production does not necessarily mean the increase in productivity. If increase in production is attributed to the increase in the inputs of production in the same proportion, the production will have increased but productivity may have declined or may remain constant because the ratio of output and inputs has shown a decline or has not shown any improvement.

Problems and Solutions

Problem: 1 In a particular plant there are 10 workers manufacturing a single product and the output per month consisting of 25 days of that particular product is 200. How much is the monthly productivity?

Solution:

Monthly productivity per worker = $\frac{200}{10}$ = 20 units

Problem: 2 There are two industries A and B manufacturing hose couplings. The standard time per piece is 15 minutes. The output of two small scale industries is 30 and 20 respectively per shift of 8 hours. Find the productivity of each per shift of 8 hours. What is the expected production of each per week consisting of 6 days?

Solution:

$$\text{Productivity} = \frac{\text{Actual production}}{\text{Standard production}}$$

Standard production of hose complings per shift = $\frac{8 \times 60}{15}$ = 32 pcs.

Productivity of industry A = $\frac{30}{32} = \frac{15}{16}$ and productivity of industry B = $\frac{20}{32} = \frac{5}{8}$

If the productivity is expressed in percentage, the same for A is $\frac{15}{16} \times 100 = 93.75\%$

and productivity of industry B is $\frac{5}{8} \times 100 = 62.5\ \%$

Production per week of industry A = 30 × l6=480 nos.

Production per week of industry B = 20 × 6= 120 nos.

Problem: 3 The following data is available for a machine in a manufacturing unit:

Hours worked per day	8
Working days per month	25
Number of operators	1
Standard minutes per unit of production	
Machine time	22
Operator time	8
Total time per unit	30

(i) If plant is operated at 75% efficiency, and the operator is working at 100% efficiency, what is the output per month?

(ii) If machine productivity is increased by 10% over the existing level, what will be the output per month?

(iii) If operator efficiency is reduced by 20% over the existing level, what will be the output per month?

Solution:

(a) Hours worked per day = 8
Working days per month = 25
Hours worked per month = 25 × 8 = 200 hrs.
Machine time = 22 minutes
Operator time = 8 minutes
Total per unit = 30 minutes = ½ hr.

No. of units produced/month/operator = $\frac{200}{1/2} = 400$

As the no. of operator is 1, monthly production = 400 units. As the plant operates at 75% efficiency.

Monthly production = $400 \times \frac{75}{100}$ = 300 units.

(b) If machine productivity is increased by 10% i.e. Machine time = $22 \times \frac{100}{(100+10)}$ = 20 minutes.

Then, total time = 20 + 8 = 28 minutes

Monthly production = $\frac{400\times 30}{28}\times\frac{75}{100} = 321\,\text{units.}$

(c) If operator efficiency reduced by 20% i.e.

Operator time = 8 x $\frac{(100+20)6}{100}$ = 8 × 7.2 = 57.6 minutes.

Total time = 22 + 57.6 = 79.6 minutes.

Monthly production = $\frac{400\times 30}{79.6}\times\frac{75}{100} = 113.06\,\text{units} = 113\,\text{units.}$

Problem : 4

An incentive scheme allows proportionate production bonus beyond 100% performance level.

Calculate the amount of (i) incentive bonus and (ii) total payment received by an operator on a particular day during, which the following particulars apply:

Operation	:	Assembling pocket transistor radio set
Work content	:	30 standard minutes per assembled set
Attended time	:	8 hours
Time spent on unmeasured work	:	2 hours
Number of sets assembled during the day	:	15
Wage rate	:	Rs. 4/- per hour

(iii) What is the labour productivity achieved by the operator during the day?

Solution:

Attended time = 8 hrs. Time spent for unmeasured work = 2 hrs.

Actual time for production = 8 – 2 = 6 hrs.

Standard assembling period = 30 minutes/set. Standard production

$= \frac{6}{30} \times 60$ set = 12 sets, in 8 hrs.

Wage rate = Rs.4/hr = 4 × 8/day = Rs. 32/day.

For 12 set of assembling Rs.32 is the wage

For 1 set of assembling $\frac{32}{12}$ is the wage

For 15 set of assembling = $\frac{32}{12}$ × 15 is the wage = Rs. 40/-

Total payment = Rs. 40/-
Incentive bonus = Rs. (40 – 32)/- = Rs. 8/-

Labour productivity = $\frac{\text{Standard Time}}{\text{Actual Time}}$

Actual Time = $\frac{6 \times 60}{15} = 24$ minutes.

Labour productivity = $\frac{30}{24} \times 100 = 125\%$

Problem: 5

The following data is available for a manufacturing unit :

No. of operators	:	15
Daily working hours	:	8
No. of days per month	:	25
Std. production per month	:	300 units
Std. Labour hours per unit	:	8

The following information was obtained for November 2007:

Man days lost due to absenteeism	:	30
Unit produced	:	240
Idle Time	:	276 man hours

Find the following:—

(a) Percent absenteeism

(b) Efficiency of utilisation of labour

(c) Productive efficiency of labour

(d) Overall productivity of labour in terms of units produced per man per month.

Solution:

No. of days per month = 25

Daily working hrs. = 8

No. of operators = 15

No. of Man days = 15 × 25 = 375 Man days.

Total working hrs. = 375 × 8 = 3,000

Hours lost in absenteeism = 30 × 8 = 240

i) Percent absentees $= \frac{240\,\text{hrs.} \times 100}{3000\,\text{hrs}} = 8\%$

ii) Efficiency of utilisation of labour $= \frac{\text{Standard labour hour to produce 240 units}}{\text{Total labour hour}} = \frac{240 \times 8}{3000} = 64\%$

iii) Standard time required to produce 240units = 240 × 8 = 1920 labour-hours.

In November, man hours lost = 30 × 8 = 240

„ „ idle time = 276

Total loss of time = 516 hours.

Productive hours available in November = 3000

Less, Total loss of time = 516

Actual labour-hours = 2484 hours

Efficiency of labour $= \frac{\text{Std.Labour hrs.}}{\text{Actual Labour hrs.}} = \frac{1920 \times 100}{2484} = 77.3\%$

v) 15 men produces 300 units,

Std. labour productivity = 300/15 = 20 units.

In November, overall productivity = 240/15=16 units. (Ans.)

i.e. productivity falls by 25%.

Problem: 6

A product is manufactured at the rate of 200 units per 4 day and sold for Rs. 8/- each. Direct material cost is Rs.2/- per unit and direct labour cost is Re.1/- per unit, overheads (including selling) are Rs. 800/- per day. If the selling price can be reduced by Re.1/- per unit, it is expected that 50% more units can be sold. The workmen are prepared to produce 50% more only if there is a proportionate increase in their earnings. A suitable incentive scheme would cost Rs. 100/- per day to administer. With appropriate calculations justify if the Company should go in for such an incentive scheme.

Solution:

Production/day = 200 units/day = Rs. 200/- × 8 = Rs. 1600

Direct material cost = Rs. 2/-

Direct labour cost = Re. 1/-

Total = Rs. 3/-

Over head = Rs. 800/day = 800/100= Rs. 8/- per unit

Profit = 8 – 7 = Re. 1/per unit = Rs. 200/ day

If selling price = Rs. (8 – 1)/- = Rs. 7/- per unit

No. of unit sold / day = $200 \times \frac{150}{100} = 300$

50 % increase in labour cost, i.e. it will be	Rs. 300/- day.
Direct Material cost = Rs. 2/- unit	Rs. 600/- day.
Overhead	Rs. 800/- day.
Extra cost	Rs. 100/- day.
Total cost	Rs. 1800/- day.

Turnover/day = 7 × 300 = Rs. 2100/-

Profit = Rs. (2100 - 1800)/- = Rs .300/- per day.

So, it is justified for the company to go in for this incentive scheme.

Incentive either on individual or on group basis plays the following role in increasing productivity: –

i) Efficiency of production is increased.

ii) Labour cost and consequently cost of production can be reduced.

iii) Incentives ensure more earning of the labour force.

iv) It increases volume of production and makes the products available at reasonable price.

v) Incentive improves productivity and helps growth of national wealth at a faster rate.

Though incentive is very much beneficial to everyone related to it (employer, employee and indirectly the society) but an incentive scheme tends to increase the material wastage if not properly guarded against.

Problem: 7

The targeted weekly output of a manufacturing unit employing 20 workers is 400 pieces. The group is entitled to earn an incentive @ 10% on the aggregate of wages based on basic piece rate plus dearness allowance (which is Rs. 120 per week) upon achievement of a minimum of 80% of the output target.

This incentive rate increases by $2^1/_2$% flat for every 10% of increase in achievement of targets up to a maximum of 10% at the level of 120% of the output target in the following manner:

Output target	Incentive rate
80% - 90%	10%
90% - 100%	12 $^{1}/_{2}$%
100% - 110%	15%
110% - 120%	17$^{1}/_{2}$%
120% and above	20%

During the four weeks in February, the actual outputs achieved by the workers are 383 pieces, 442 pieces, 350 pieces and 318 pieces respectively. The average basic piece rate is Rs. 5. Compute the amount of incentive earned by the group during each of the four weeks.

Solution:

Computation of Incentives in February

	Week			
	1st	2nd	3rd	4th
Actual output achieved	383	442	350	318
Achievement percentage				
(Actual output/ Targeted output)	95.75	110.5	87.5	79.5
Wages at basic piece rate of Rs. 5	1915	2210	1750	1590
Dearness allowance	120	120	120	120
Total	**2035**	**2330**	**1870**	**1710**
Incentive (%)	12.5	17.5	10	Nil
Incentive earned by group				
(Total x incentive %)	254.38	407.75	187	nil

Problem: 8

Payment of bonus is made in a company on the following scale on the basis of the percentage of time saved on time allowed.

Time saved (% of standard)	Bonus (% of time saved)
(a) Up to 25%	10%
(b) 26% to 30%	20%
(c) 30% and above	30%

You are required to calculate the earnings of A who takes 50 hours; B who takes 70 hours; C who takes 90 hours. The standard time is 100 hours and the wage rate is Rs. 3 per hour.

Solution:

	A	B	C
Standard time	100hrs.	100hrs.	100hrs.
Time taken	50hrs.	70hrs.	90hrs.
Time saved	50hrs.	30hrs.	10hrs.
% of the time saved on standard time	50 %	30 %	10 %
Time wages (Time taken x Rs.3)	Rs. 150.00	Rs.210.00	Rs.270.00
Bonus up to 25 %	7.50	7.50	3.00
Bonus up to 30 %	3.00	3.00	-
Bonus up to 30 %	18.00	-	-
Total earnings	178.50	220.50	273.00

Problem: 9

Workmen of a particular grade working on 8-hour shift duty are guaranteed a wage of Rs. 32. An incentive scheme is in operation according to which production bonus is earned directly proportional to performance but only after 100% performance is reached. Four workmen A, B, C and D produce 48, 60, 75 and 90 units respectively in 6 hours spent on working on a job which has a standard time of 6 minutes per unit as measured work content. Remaining 2 hours of the shift are spent in doing unmeasured work for which no incentive bonus can be paid. Find for each workman: (i) the production performance level achieved, (ii) total earnings for the day.

Solution:

Rs. 32 Here the general base wage rate = Rs. 32 / 8 = Rs. 4 per hour

(i) Production performance levels

Workman	A	B	C	D
Standard units produced at 6 minutes per unit (s)	S = 48 × 6 = 288	60 × 6 = 360	75 × 6 = 450	90 × 6 = 540 mins.
Time worked on measured work for 6 hours (T)	360	360	360	360 mins.
Thus, performance (S/T) x 100	(288/360) × 100 = 80%	(360/360) × 100 = 100%	(450/360)× 100 = 125%	(540/360) × 100 = 150%

(ii) On the basis of this information, let us calculate total earnings for the day.

	A	B	C	D
Earnings on unmeasured work for 2 hours @ Rs. 4 per hour	Rs. 8	Rs.8	Rs. 8	Rs. 8
Earnings on measured work for 6 hours @ Rs. 4 per hour plus performance bonus when performance exceed 100%	Rs. 24	Rs. 24	Rs. 30	Rs. 36
Total earnings for the day	Rs. 32	Rs. 32	Rs. 38	Rs. 44

Here C and D get bonus of Rs. 6 and Rs. 12 respectively because their performance is 25% and 50% respectively higher than 100%.

Problem: 10

Fair Play Co. Ltd. has introduced a Scanlon Plan of Incentive Bonus for its employees in 200 based on the following information relating to the previous three years:

Years	Sales Revenue	Total Salaries and Wages
2004	1,20,000	36,000
2005	1,25,000	35,000
2006	1,35,000	35,100

For 2007 the Sales Revenue has been Rs.1,50,000 and the total salary and wage payment has been Rs. 36,000. What is the amount due as Bonus to the employees according to Scanlon Plan? If 30% is set aside in a bonus equalisation reserve fund, how much money is available to be paid out as Scanlon Bonus for 2007?

Solution:

Ratio of Labour cost to sales revenue = Total Salaries & Wages / Sales Revenue

For, 2004 = 36,000/120,000 = 0.30 ; For 2005 = 35,000/125,000 = 0.28 and 2006

= 35,100/1,35,000 = 0.26

Average for three years = 0.84/3 = 0.28; Expected Labour Cost on Sale Revenue of 2007

= 0.28 × 1,50,000 = Rs. 42,000;

Actual Labour Cost (Salaries & Wages for 2007) = Rs. 36,000. Savings in labour cost due to increased productivity = Rs. 6,000. If 30% is set aside in a bonus equalisation reserve fund, the bonus for 2007 will be = Rs. 6,000 – Rs. 1,800 (30% of 6,000) = Rs. 4,200.

Problem: 11

An incentive scheme allows proportionate production bonus beyond 100% performance level. Calculate the amount of (i) Incentive bonus and (ii) Total payment received by an operator on a particular day during which the following particulars apply:

Operation	:	Assembling pocket transistor radio set
Work Content	:	30 Standard minutes per assembled set
Attended Time	:	8 Hours
Time spent on unmeasured work	:	2 Hours
Numbers of sets assembled during the day	:	15
Wage rate	:	Rs. 4 per hour

(iii) What is the net labour productivity achieved by the operator during the day?

Solution:

Total standard minutes worked during the day = 30 × 15 = 450, working time = 8 – 2 = 6 hours = 360 minutes. Performance = (450 × 100) /360 = 125% or 0.25

(i) Incentive bonus = 0.25 × 6 × 4 = Rs. 6 for six hours on measured work

(ii) Guaranteed wage for 8 hours = 8 × 4 = Rs. 32; Total earnings for the days

= Rs. (6 + 32) = Rs. 38

(iii) Net labour productivity = Output in units / Net man hours = 15 / 6 = 2.5 sets per hour

Problem: 12

The following data is available for a machine in a manufacturing unit:

Hours worked per day	8
Working days per month	25
Number of operator	1
Standard minutes per unit of production: Machine time	22
Operator time	8
Total per unit	30

(i) If plant is operated at 75% efficiency, and the operator is working at 100% efficiency, what is the output per month?

(ii) If machine productivity is increased by 20% over the existing level, what will be the output per month?

(iii) If operator efficiency is reduced by 20% over the existing level, what will be the output per month?

Solution:

(i) If plant is operated at 75% efficiency, output per month = (Actual Time / Standard Time) × efficiency level = $\frac{25 \times 8 \times 60}{30} \times \frac{75}{100}$ = 300 units. (ii) If the machine productivity is increased by 10% actual machine time becomes (22 × 100) / 120 = 18.33 minutes; Actual total time per unit = 18.33 + 8 = 26.33 minutes.

(ii) Output per month = (8 × 60 × 25 × 75) / (26.33 × 100) = 342 units.

(iii) If operator's efficiency is reduced by 20% operator time becomes = (8 × 100) / 80 = 10 mts; Actual total time per unit = 10 + 22 = 32 mts.; Output per month = (8 × 60 × 25 × 75) / (32 × 100) = 281.

Problem: 13

An operator is paid a flat rate of Rs. 30 per day and Re. 1 per every additional 5 points of efficiency rating over a rating of 100 which represents standard performance, as incentive bonus. The standard minutes per unit of production are 20 and the operator makes 27 units in a shift of 7.5 working hours. (i) How much incentive bonus he would get per day? (ii) If the incentive system is modified to pay the incentive at the rate of 50% of the time saved, what incentive would he get?

Solution:

(i) Standard performance (100 points) = (7½ hours × 60) ÷ 20 = 22.5 units; Actual performance = 27 units. Efficiency rating % = (27 / 22.5) × 100 = 120%; Incentive bonus per day = (20/5) × 1 = Rs. 4/-

(ii) Time required for producing 27 units; 27 × 20 = 540 minutes.

Time actually spent = 7½ × 60 = 450 minutes

Time saved = 90 minutes; Incentive bonus = $\frac{90 \times 30}{450} \times 50\%$ =Rs. 3/-

Problem: 14

The following information about a company is available

Year	Sales Revenue (Rs.)	Total employee Remmeration (Rs.)
2004	2, 40,000	72, 000
2005	2, 50, 000	70, 000
2006	2, 70,000	70, 200

For 2007, the sales revenue has been Rs. 3, 00,000 and the employee remuneration has been Rs. 72,000. What would be the amount due to the employees, if a Scanlon Plan is introduced?

Solution:

Average sales revenue for three years period
= Rs. (2,40,000 + 250000 + 270000) / 3 = Rs. 253333.33/-
Average employee remuneration = (72,000+70,000+70,200) / 3 = Rs. 70,733.33/-

Total bonus = Rs. 3,00,000 $\times \frac{\text{Rs.}70{,}733.33}{\text{Rs.}2{,}53{,}333.33} = \text{Rs.}84{,}000$ (approx.)

∴ Amount due to employees = 84,000 – 72,000 = Rs. 12,000/-

Problem: 15

Manufacture of a component requires operations to be performed on three machines P, Q and R respectively, the standard times and operator efficiency being as follows:

If the factory operates 2 shifts of 8 hours each and the machines are available for production throughout

Machine	Standard hours per component	Operator efficiency
P	0.16	80%
Q	0.23	100%
R	0.09	90%

the shifts on six days in a week, how many of machines P, Q and R will be required to produce 4,800 components per week? How many hours of capacity, if any, would be available from the machines P, Q and R for doing other jobbing work?

Solution:

Available hours = 6 days × 2 shifts × 8 hours = 96 hours.
Actual hours Required
= (Standard hrs. per unit × Production quantity) / Operator efficiency

Machine P = (0.16 × 4800) / 80% = 960 hours; Machine Q = (0.23 × 4800) / 100% = 1104 hours

Machine R = (0.09 × 4800) / 90% = 480 hours; No. of machines required = (Actual hours required / Available hours); P = 960 / 96 = 10 machines; Q = 1104 / 96 = 11.5 i.e., 12 machines; R= 480 / 96 = 5 machines.

Machines P and R will be fully utilised with no spare capacity. Machine Q will have ½ machine to spare, i.e., ½ × 96 = 48 hours per week can be utilised for doing other jobbing work.

Problem: 16

Workmen of a certain grade are guaranteed a wage of Rs. 48 for an eight hour shift. An incentive scheme is in operation which pays production hours directly proportional to production performance only after 100% level is reached. Four workmen P, Q, R and S produce 90, 75. 60 and 48 units respectively in 6 hours. Work content of the job is 6 standard minutes per unit. Remaining 2 hours of the shift are spent on doing miscellaneous unmeasured work for which no incentive hours can be paid.

Workmen	P	Q	R	S
Units produced in 6 hours spent on measured work	90	75	60	48
Standard minutes per unit (s)	6	6	6	6
	540	450	360	288
Minutes worked in measured work 6 hours (A)	360	360	360	360
Performance = S /A × 100	$\frac{540}{360}\times 100$	$\frac{450}{360}\times 100$	$\frac{360}{360}\times 100$	$\frac{288}{360}\times 100$
	= 150%	= 125%	= 100%	= 80%
Earnings on measured work for 6 hours	= 36 × 1.5	= 36×1.25	= 36 × 1	= 36 × 1
	= Rs. 54	= Rs. 45	= Rs. 36	= Rs. 36
Earning on unmeasured work for 2 hours @ Rs. 6 per hour	12	12	12	12
Total earning for the 6 hours shift	= Rs. 66	= Rs. 57	= Rs. 48	= Rs. 48

Solution:

Performance of R at 100% and S at 80%. Both earn Rs. 48 for the 8 hours shift. This is a problem with incentive schemes with ' guaranteed base wage' . If S does not improve to 100% performance after a period, he may be transferred to unmeasured work.

Problem: 17

An operator manufactures 11 identical components in a week of 48 hours duration. Each component takes 360 standard minutes. Estimate the cost per component if the company operates an incentive system as below.

Guaranteed basic rate is Rs. 4 per hour upto 80% performance level, 11% of the basic rate is paid if the performance level is between 80% and 100% and 120% of the rate is paid if the performance level falls between 101 and 110%. Above 110% performance level, 130% of the basic wages are paid. Materials component of each job is 150% of the direct labour.

Solution

Standard performance per week = (48 × 60) / 360 = 8 components

Actual performance per week = 11 components; Efficiency level = 11/8 × 100 = 137.5%. As the

performance level exceeds 110%, 130% of the basic wages are payable.
Wage Rate = (Rs. 4 × 130)/ 100 = Rs. 5.20 per hour

Labour cost (48 × 4 × 130)/(11×100)	= Rs. 22.69
Material cost	= Rs. 20.00
Over head cost @ 150% of direct Labour	= Rs. 34.04
Total cost per component	= Rs. 76.73

Problem: 18

A company manufactures 200 units of a product everyday and sells it for Rs. 8 each. Direct material cost is Rs. 2 per unit and direct labour is paid Re. 1 per unit. Overheads are Rs. 800 per day in total. A market research survey indicates that 300 units can be sold per day if the price can be brought down to Rs. 7. Production can be increased to this level, if an incentive scheme which would cost Rs. 100 per day to administer is implemented, giving the workmen proportionate increase in their earnings. Examine with appropriate calculations whether and, if so, how much gains are made by the company and the workmen. Comment on the social desirability of such incentive schemes.

Solution:

Direct material cost per unit = Rs. 2; Direct labour cost per unit = Re. 1

Total revenue for 200 units = 200 × 8 = Rs.1600;

Total cost for 200 units = Rs. 800 + (200 ×3) = Rs. 1400; Profit: 200

Total revenue for 300 units = 300 × 7 = 2100;

Total cost for 300 units = Rs. 800 + Rs. 100 + (300 × 3) = Rs.1800

Profit: 300. Gains made by the company from the incentive scheme

= Rs. 300 – Rs. 200 = Rs. 100

Gains made by workmen = Rs.100. Such incentive schemes are socially desirable as both workmen and the company stand to gain. Consumers also gain because the product is available at a lower price.

Problem: 19

A company operates a wage incentive plan as follows:

Productivity Level Total incentive in a month

	Rs. (lacs)
Less than 75%	Nil
75% to 76%	1
76.1 to 77%	2
77.1 to 78%	3
78.1 to 79%	4
79.1 to 80%	5
80.1 and above	6

The total incentive is shared by the workers with hours worked by each as the basis. In a month the output was 80,000 standard hours. There are 600 workers, the total hours worked being 90,000 in the month, (i) What is the overall productivity? (ii) What is the total incentive? (iii) A worked for 150 hours and B for 200 hours. What are their individual earnings?

Solution:

(i) Overall productivity= (80,000 / 90,000) × 100 = 88.89% (ii) Total incentive = Rs. 6 lacs (iii) Earnings of A = (6,00,000 /90,000) × 150 = Rs. 1,000; Earnings of B = (6,00,000 /90,000) × 200 = Rs. 1,333.33

Problem: 20

A soap factory adopts the piece rate system for its packing section, the rate being 10 paise. There is a guaranteed wage of Rs. 20 per day. The following data is available in regard to the number of soap cakes packed per day.

Worker	No. of soap cakes packed
A	800
B	600
C	100
D	700

(a) (i) What is the wage payable to each worker? (ii) What is the average cost of packing per soap cake for the day?

(b) The standard time for packing is 4 minutes in the above example.(i) What is the labour productivity of each worker for a shift duration of 480 minutes?(ii) What is the productivity of the group? (iii) Give your comments on the productivity figures obtained.

Solution:

(i) Wages payable are – (A) 800 × 0.10 = Rs. 80; (B) 600 × 0.10 =Rs.60; (C) 100 × 0.10 = Rs. 10

= Rs. 20 (guaranteed wage) ; (D) 700 × 0.l0 = Rs.70

(ii) Average cost of packing per soap for the day

$$= \frac{80+60+20+70}{800+600+100+700} \times 100 = 23000/2200 = 10.45 \text{ Paise approx.}$$

(b) (i) labour productivity of each worker (A) : [800 ÷ (480/4)] × 100 = 666.7%; (B) : [600 ÷ 480 / 4] × 100 = 500%; (C): [100 ÷ 480 / 4] × 100 = 83.3% ; (D): [700 ÷ 480 / 4] × 100 = 583.3%

(ii) Productivity of the group $= [(800 + 600 + 100 + 700)] \div \frac{480 \times 4}{4} \times 100 = 458.3\%$,

(iii) Productivity figures of all the workers except C are excellent. Group productivity is also quite good.

Problem: 21

The time study section of a tyre factory has fixed the following work standards for the tyre trimming section:

Size of Type	Standard Time (Man – Mins)
Tractor 10	
Truck 6	
Passenger-car	4
Scooter 2	

Production data for 2 groups are as follows —

	Group I	Group II
No. of men	10	10
Hours worked	8	8
Production - Tractor	100	50
Truck	200	250
Passenger-car	–	50
Scooter	200	100

(i) What is the productivity of each group? (ii) What is the overall productivity of both groups combined? (iii) Each worker is paid a basic wage of Rs. 50 per day, D.A. of Rs. 60 per day and incentives as per the scheme shown below:

Productivity	Rate / day (Rs.)
<49%	0
50 – 60 %	10
60 – 70 %	20
> 70 %	40

What will be the total wages of a worker in Group I and a worker in Group II?

Solution:

(i) Productivity of Group I:—

Standard time = 100 × 10 + 200 × 6 + 200 × 2 = 2600 Man-Mins.

Actual time taken = 10 × 8 × 60 = 4800 Man-Mins.

Productivity = (2600 / 4800) × 100 = 54%.

Productivity of group II:—

Standard time = 50 × 10 + 250 × 6 + 50 × 4 + 100 × 2 = 2400 Man-Mins.

Actual time taken = 10 × 8 × 60 = 4800 Man-Mins;

Productivity = (2400 /4800) × 100 = 50 percent

(ii) Overall productivity of both groups combined, standard time

= 2600 + 2400 Man-Mins = 5000 Man-Mins.

Actual time = 4800 + 4800 = 9600 Man-Mins;

Productivity = (5000 /9600) × 100 = 52 per cent

(iii) Total wages of a worker = Basic wage + DA + incentive

Group I = Rs. 50 + 60 + 10 = Rs. 120, Group B = Rs. 50 + 60 + 10 = Rs. 120

Problem: 22

A shop undertaking piece work and word processing job has the following working systems. There are four operators A, B, C and D. Each one is given a minimum guaranteed wage of Rs. 50 for a working day for keying in and taking out printing of 25 pages. For any extra page they are given Rs. 3. Following data is available by each operator for a week of 6 days.

Operator	Number of pages completed
A	200
B	180
C	150
D	220

(a) What is the remuneration payable to each worker? Does the cost per page depend on quantity? Any variation from normal? (b) How do you incorporate quality incentive in the system?

Solution:

(a) Standard production = 25 × 6 = 150 pages. Standard remuneration = 50 × 6 = Rs. 300

Operator	Number of pages completed	Excess over Standard output	Incentive payment
A	200	50	50 ×3 = Rs. 150
B	180	30	30 ×3 = Rs. 90
C	150	0	0
D	220	70	70 ×3 = Rs. 210

Thus, the remuneration payable to each operator is as follows:

A	Rs. 300 + Rs. 150	= Rs. 450
B	Rs. 300 + Rs. 90	= Rs. 390
C	Rs. 300 + 0	= Rs. 300
D	Rs. 300 + Rs. 210	= Rs. 510

Cost per page does not depend upon quantity. The incentive scheme is unbalanced due to low benefit for management.

Problem: 23

Workmen in a particular grade are guaranteed a daily wage of Rs. 64 for an eight hour shift. According to an incentive scheme in operation, incentive bonus is earned directly proportional to production above 100%. Four workmen A, B, C and D produce 48, 60, 75 and 90 units respectively in six hours spent in working on a job which has standard time of 6 minutes per unit. The remaining 2 hours are spent in doing some unmeasured work for which no incentive bonus can be paid. For each of the four workmen find:

(i) the level of production performance achieved ;(ii) the total earnings for the day.

Solution:

Here the general base wage rate 64/8 =Rs. 8 per hour

(i) The level of production performance achieved:

Workmen	A	B	C	D
Standard units produced at 6 minutes per unit (S)	48 × 6 = 288	60 × 6 = 360	75 × 6 = 450	90 × 6 = 540
Time worked on measured for 6 hours (T)	360	360	360	360
Performance (S/T) x 100	80	100	125	150

(ii) Total earnings per day:

Earnings on unmeasured work for 2 hours @ Rs. 8 per hour	16	16	16	16
Earnings on measured work for 6 hours @ Rs. 8 per hour Performance	48 –	48 –	48 12	48 24
Rs.	64	64	76	88

Problem: 24

The packing section in a detergent factory operates under the guaranteed piece rate system of wage payment. The piece rate per cake packed is 20 paisa. The guaranteed wage per day is Rs. 35. On a typical day, the production of four workers in the packing department is as follows:

Worker	No. of cakes packed
A	400
B	300
C	175
D	150

(i) What are the earnings of each worker on this day?

(ii) What is the average labour cost of packing on this day?

(iii) The management wants to do away with the present individual incentive system and instead introduce a group incentive system for all the 4 workers together (i.e.) giving them a flat incentive of Rs. 15 per day per worker if the combined production for the day exceeds 1,000 nos. and Rs. 20 per day per worker if the output exceeds 1,300 nos. What would be your advice to the management in this regard? You may assume a standard time per unit as 1.333 minutes and that the management saves Rs. 5 per day in the administration of the new group incentive scheme as compared to the earlier one.

Solution:

Given piece rate = Re. 0.20 per piece. Guaranteed wage rate = Rs. 35 per day. Payment as per guaranteed piece rate system.

(i) Computation of earnings:

Worker	Nos. packed	Piece rate (Rs.)	Guaranteed rate (Rs.)	Earnings payable
A	400	80	35	80
B	300	60	35	60
C	175	35	35	35
D	150	30	35	35
	1025			210

(ii) Average labour cost or packing: Labour cost = Rs. 210; Nos. packed = 1,025; Cost per pack = Re. 0.20 (approx.) (iii) Evaluation of the group incentive scheme: Standard time per unit = 1.333 mins.; Standard output for 4 persons = (480/1.33) × 4 = 1,440; Earnings based on this scheme in the present case: Normal wage = Rs. 140;

Incentive = Rs. 15 × 4 = Rs. 60; Actual cost = Normal wage + Incentive – Savings.

= Rs. (140 + 60 – 5) = Rs. 195

Since the group incentive costs are less than the present guaranteed scheme, management should go for it.

Problem: 25

(a) Find out the productivity index of a section from the following figures:

(i) Standard Man-Hrs:

Job Cards	Std. Hrs	No. of persons
1	17	3
2	15	2
3	19	3
4	18	3
5	23	5
6	16	5
7	22	3
8	14	4

(ii) Idle Card:

Reasons	Idle time (Hrs.)	No. of persons involved
No work	10	1
No Material	5	2
Power Failure	10	15
No Material Handling Equipment	2	3
Machine Breakdown	10	4
Others	5	3

(iii) Record of attended hours for direct workers :

Workers	Attended Hrs.
3	180
5	170
4	160
3	150

Compute: Productivity Index and Wastivity Index.

b) Do you agree with the view "Job security is an impediment to productivity"? Justify your answer.

Solution:

(a) Standard Man Hrs Produced (S.M.H.) would be = Std. hrs x no. of persons for each job.

= 17 × 3 +15 × 2+ 19 × 3 + 18 × 3 + 23 × 5 + 16 × 5 + 22 ×3 + 14 × 4 = 51 + 30 + 57 + 54 + 115 + 80 + 66 + 56 = 509 hrs.

Attended Man-hrs (A.M.H.) = Attended hrs. × No. of workers

(as per record of attended hrs. for direct workers — as given)

= 180 × 3 + 170 × 5 + 4 × 160 + 3 × 150

= 540 + 850 + 640 + 450 = 2480 hrs.

Idle man-hrs = Idle Hrs (as given) × no. of persons involved = 10 × 1 + 5 × 2 +10 × 15+ 2 × 3 +10 × 4 + 5×3 = 231 hrs.

Effective A.M.H. = 2480 – 231 = 2249 hrs. Productivity index (P.I.) = (509 / 2,249) × 100 = 22.63%

Wastivity = 100 – 22.63% = 77.37%

(b) I agree with this statement especially with reference to our country. In general, a worker has no incentive or pressure to improve his productivity when there is no likelihood of losing his job despite low levels of performance. In Government jobs, in public sector and in industries where powerful trade unions exist, productivity tends to be low because workers know them. In this type of work culture it is not possible to increase productivity. Therefore, general productivity levels remain low. On the other hand, if workers know that they will lose their jobs in case they fail to give a minimum level of productivity; they would work hard to retain their jobs. There would be a continuous pressure on them to perform better. According to behavioural scientists human beings tend to perform better under a little tension. This tension at the work place can be created if job security is not guaranteed. At the same time safeguards must be provided to ensure that a worker is not thrown out of the job on frivolous grounds or for reasons which are not his responsibility. Suitable legislation can be created to protect workers against victimisation. Thus, absolute job security is an impediment to productivity in India.

Problem: 26

A product is manufactured at the rate of 200 units per day and sold for Rs. 8 each. Direct Material cost is Rs. per unit and direct labour cost is Re. 1/- per unit, overheads (including selling) are Rs. 800 per day.

If the selling price can be reduced by Re. 1/- per unit, it is expected that 50% more units can be sold. The workmen are prepared to produce 50% more only if there is a proportionate increase in their earnings. A suitable incentive scheme would cost Rs. 100 per day to administer. With appropriate calculations, justify if the company should go in for such an Incentive Scheme.

Solution:

Comparative cost and profitability: (per day)

Particulars	Without Incentive (Rs.)	With Incentive (Rs.)
Units produced & sold	200	300
Selling price – Rs.	8	7
Sales value – Rs.	1,600	2.100
Direct cost: Direct Materials at Rs. 2 per unit	400	600
Direct Labour cost at		
Rs.1/- per unit	200	300
	600	900
Contribution : (Sales - Direct cost)	1,000	1,200
Overheads	800	800
Incentive	—	100
Profit	200	300

Problem: 27

The following information is available for a factory:

Daily working hours	8
No. of working days in a week	6
No. of operators	20
Std. Hours per unit of production	4

During a particular week

Number of units produced	48
Absentee man days	40
Idle time due to load shedding	30 Mandays

Find:

(i) Absenteeism percentage

(ii) Labour utilisation percentage

(iii) Productive efficiency of labour

(iv) Overall productivity of labour in terms of units produced/week/employee.

Solution:

(i) Absenteeism percentage = $\dfrac{\text{Absentee mandays / week}}{\text{Total operator mandays / week}} = \dfrac{40}{2 \times 6} \times 100 = 33.33\%$

(ii) Labour utilisation percentage = $\dfrac{\text{Working mandays / week}}{\text{Attended mandays / weeks}} \times 100$

$$= \frac{\text{Total operator mandays / week} - \text{Absenteeism} - \text{Idle time}}{\text{Attended mandays}} \times 100$$

$$= \frac{(20 \times 6) - 40 - 30}{(20 \times 5) - 40} \times 100 = 62.50\%$$

(iii) Productive efficiency of labour $= \dfrac{\text{Std. man hours produced / week}}{\text{Actual man hours worked / week}} \times 100$

$$\frac{4 \times 48}{[(20 \times 6) - 40 - 30] \times 8} \times 100 = 48\%$$

(iv) Overall productivity of labour $= \dfrac{\text{Total production / week}}{\text{Total operators}} = 48 / 20$

= 2.4 Units/Week /operator

Problem: 28

A factory can manufacture two products A and B by using either of two materials P or Q. A is expected to sell at Rs. 70 per unit and product B at Rs. 30 per unit.

		Material P	Material Q
Output	A	200 units	400 units
	B	300 units	200 units
Quantity, of raw material usage		1,000 kg	1,000 Kg
Labour usage		300 man hrs.	250 man hrs.
Electric energy consumption		1000 KWhr	1500 KWhr
Cost of raw material/kg		Rs.20	Rs.30
Labour per manhour		Rs.5	Rs.5
Electrical energy/KWhr		Rs.1.5	Rs.1.5

The operating data are as follows:

Compare the productivity of material, labour and electrical energy in using materials P and Q. Comment on the relative advantage of using either of the materials.

Solution:

Productivity $= \dfrac{\text{Value of output}}{\text{Value of input}}$

Sales value of output with material P

= Output of product A in units × Rate/unit of A

+ Output of product B × Rate/unit of B= 200 × 70 + 300 × 30 = Rs. 23,000

Sales value of output with material Q = 400 × 70 + 200 × 30 = Rs. 34,000

The partial productivity of different factors of production are computed as follows:

	Material P	Material Q
1. Productivity of raw materials $= \dfrac{\text{Sales value of output}}{\text{Value of raw material used}}$	$\dfrac{23000}{1000\times 20} = 1.150$	$\dfrac{34000}{30000} = 1.133$
2. Labour productivity, i.e., $= \dfrac{\text{Sales value of output}}{\text{Value of labour}}$	$\dfrac{23000}{300\times 5} = 15.333$	$\dfrac{34000}{250\times 5} = 27.200$
3. Electrical energy productivity, i.e., $= \dfrac{\text{Sales value of output}}{\text{Value of electrical energy}}$	$\dfrac{23000}{1000\times 1.5} = 15.333$	$\dfrac{34000}{1500\times 1.5} = 15.111$

Comments:

The productivities of (1) and (3) is nearly same by using either material P or Q. If labour is the key factor it is better to use material Q as labour productivity, for Q is higher, i.e., 27.200 > 15.333

Problem: 29

The following data is available for a machine in a manufacturing unit.

Number of hours worked per day	8
Working days per month	25
Number of operators	1

Standard time per unit of production,

Machine time	22 min
Operator time	08 min
Total time/unit	30 min

(i) If plant is operated at 75% efficiency, and the operator is working at 100% efficiency, what is the output per month?

(ii) If the machine productivity is increased by 10% over the existing level, what will be the output per month?

(iii) If the operator efficiency is reduced by 10% over the existing level, what will be the output per month?

Solution:

(i) Plant is operated at 75% efficiency

Machine time $= 22 \times \dfrac{100}{75} = 22 \times \dfrac{4}{3}$ min

Operator time = 8 min

Total time/unit $= \dfrac{22\times 4}{3} + 8 = \dfrac{112}{3}$ min

Total time available = 8 × 60× 25 min

Number of units produced per month $\dfrac{8 \times 60 \times 25}{(112/3)}$ = 321.43 ≈ 322 units.

(ii) If the machine productivity is increased by 10%, i.e., plant efficiency = 75 + 10 = 85%.

Machine time = $\dfrac{22}{0.85}$ = 25.88 min

Operator time = 8 min (assuming 100% efficiency)

Total time/unit = 33.88 min.

Number of units produced/month = $\dfrac{8 \times 60 \times 25}{33.88}$ = 354.19 ≈ 355 units.

(iii) If the operator efficiency is reduced by 20%, plant efficiency is 75%.

Machine time = $\dfrac{22}{0.75}$ = 29.33 min

Operator time = $\dfrac{8}{0.9}$ = 9 min/unit (operator efficiency 90%)

Total time/unit = 29.33 + 9 = 38.33 min

Number of units produced/month = $\dfrac{8 \times 60 \times 25}{38.33}$ = 313 unit S

Problem: 30

The targeted weekly output of a manufacturing unit employing 20 workers is 400 pieces. The group is entitled to earn an incentive @ 10% on the aggregate of wages based on basic piece rate plus dearness allowance (which is Rs. 120 per week) upon achievement of a minimum of 80% of the output target. This incentive rate increases by $2\,^1/_2$% flat for every 10% increase in achievement of targets upto a maximum of 10% at the level of 120% of the output target in the following manner :

Output Target	Incentive Rate
80% - 90%	10%
90% - 100%	$12^1/_2$%
100% - 110%	15%
110% - 120%	$17^1/_2$%
120% and above	20%

During the four weeks in February, the actual output achieved by the workers is 383 pieces, 442 pieces, 350 pieces and 318 pieces respectively. The average basic piece rate is Rs. 5. Compute the amount of incentive earned by the group during each of the four weeks.

Solution:

Calculation of incentives in February

	Week			
	1st	2nd	3rd	4th
Actual output achieved	383	442	350	318
Achievement percentage				
(Actual output/ Standard output) × 100 (383/400) × 100	95.75%	110.5%	87.5%	79.5%
Wages at piece rate at Rs. 5/-	Rs. 1,915	Rs. 2,210	Rs. 1,750	Rs. 1,590
Dearness allowance	120	120	120	120
	2,035	2,330	1,870	1,710
Incentive %	$12^1/_2$%	$17\ ^1/_2$%	10%	Nil
Incentive earned by group	Rs. 254.38	Rs. 470.75	Rs. 187	Nil

2.13 Quality Control

We are all living in a competition age. In order to combat competition, every manufacturer would like to maintain the quality of his products so that it may be liked by the users in preference to products of his competitors. Reputation for uniformity and dependability of the quality of a product is one of the most important assets which a manufacturing concern should try to acquire or not to lose if already acquired.

There is an old saying heard very often in business circles to the effect that one is reminded of quality long after price is forgotten. Yet the management often fails to appreciate fully the truth of this statement. At the time when production schedules are pressing, the tendency quite often is to sacrifice quality in favour of quantity. The tendency is reflected in customer ill-will and reduced sales volume. Poor quality or reduced quality costs the concern much indirectly.

So, in order to maintain the quality of the product, quality control is applied at the work place. Quality of raw materials and the parts and the machines and equipment should be inspected quite strictly because quality of product depends much upon the quality of raw materials. During the process of production, several checks are done through inspection of the semi-finished product and finished product and it is confirmed whether the quality of the product conforms to the standards and specifications already set. For this purpose, several devices or techniques are applied. If the quality of the product, it is found during quality control process, is found not conforming to the specifications, the steps should be taken by the production department to improve the quality of the defected articles by reworking on those articles and if it, anyhow, is not possible, other measures to sell those sub-standard items should be taken such as selling such items at reduced rates as 'B' quality items.

This topic deals with the various devices or techniques of quality control (including statistical quality control and inspection).

Quality Control – Meaning, Objects and Importance

Meaning of quality control : The term 'quality control' consists of two words 'quality' and 'control'. Quality is that characteristic or a combination of characteristics that distinguishes one article from the other or goods of one manufacturer from that of competitors or one grade of product from another when both are the outcome of the same factory. The main characteristics that determine the quality of an article may include such elements as design, size, materials, chemical composition, mechanical functioning, electrical properties, workmanship, finish and appearance. 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.

'Control' may be referred to as the comparison of the actual results (finished product) with the predetermined standards and specifications. It locates the deviations and tries to remove them. Control is the correction in the quality of the produce when deviations in the quality are more than expected in the process. Control consists in verifying whether everything occurs in conformity with the plan adopted, the instructions issued and principles established. It has for object to point out weaknesses and errors in order to rectify them and prevent recurrence. It operates on everything – things, people and action.

Thus, by the term quality control, we mean the process of control where the management tries to conform the quality of the product in accordance with the pre-determined standards and specifications. It is a systematic control of those variables that affect the excellence of the ultimate product.

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.

Quality control refers to the systematic control of those variables encountered in a manufacturing process which affect the excellence of the end product. Such variables result from the application of materials, men, machines and manufacturing conditions.

Thus 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. In this way, for quality control purposes, first standards and specifications are established and then to see whether the product conforms to those standards.

Objectives of quality control: The following are the main objectives of quality control programme:

1. To assess the quality of the raw materials, semi-finished goods and finished products at various stages of production process.
2. To see whether the product conforms to the predetermined standards and specifications and whether it satisfies the needs of the customers.
3. If the quality of the products deviates from the specifications, able to locate the reason for deviations and to take necessary remedial steps so that the deviation should not be recurred.
4. To suggest suitable improvements in the quality or standard of goods produced without much increase or no increase in the cost of production. New techniques in machines and methods may be applied for this purpose.
5. To develop quality consciousness in the various sections of the manufacturing unit.
6. To assess the various techniques of quality control, methods and processes of production and suggest improvement in them to be more effective.
7. To reduce the wastage of raw materials, men and machine during the process of production.

Importance or advantages of quality control system. The programme of quality control is advantageous to producers and consumers both. A quality product will satisfy the customer's needs on the one hand and consequently the demand of the product will increase resulting in large-scale production. On the other hand, the goodwill of the firm increases as the producer of quality goods. It helps the producer in increasing the market for the goods. The importance of quality control lies in the following facts:

- ***Reduction in costs:*** An efficient quality control system reduces the cost of production of the product due to (i) reduction in wastage of raw materials, semi-finished and finished goods; (ii) large-scale production of standard quality product; (iii) rework cost of the substandard goods is the minimum.
- ***Improvement in the morale of employees:*** By quality control programme, the employees become quality-conscious. They understand the standards of the product well and try to improve the standards and produce the quality goods to the best of their efforts. Thus it improves the morale of the employees.
- ***Maximum utilisation of resources:*** By establishing the quality control system, the necessary control over the machines, equipment, men and materials and all other resources of the company is exercised. The system will also control the misuse of facilities, wastages of all types and low-standard production. Thus, the resources of the company are put to maximum use.
- ***Increase in sales:*** Increase in sales of the product is the main objective of the quality control system. By introducing quality control programme in manufacturing process, a quality product is made available to the consumers and that is too at lower rates because of lower cost of production. It in turn increases the demand of company's product.
- ***Consumer's satisfaction***: Consumers always get the quality products of standard specifications which they find to their utmost satisfaction.
- ***Study of variations:*** It is a well-known fact that some variations are bound to exist in the nature of production inspite of careful planning. The magnitude of variations depends upon the production process namely machines, materials, operations etc. The techniques of quality control helps in the study of these variations in quality of the product, and serves as a useful tool for the solution of many manufacturing problems which cannot be solved so well by any other method.

Thus quality control is an important technique in the hands of management to maintain the quality of the product.

Meaning of inspection: Inspection is an important and essential tool of quality control that ascertains and controls the quality of a product. The main purpose of quality inspection is to safeguard quality by comparing materials, workmanship and pro ducts with the set standards. Inspection is a method by which the inspector may decide how much of the total work done conforms with the pre-determined standards or how much is below-standards so that a decision may be taken for its approval or rejection. If it conforms to specifications, it will be accepted otherwise the whole lot or a part of it which does not conform to standards will be rejected. If defects in the items are beyond acceptable limits, a corrective action can also be suggested so that the future production should be strictly according to the specification because, the fundamental purpose of inspection is to have an effective check on the production of defective items to ensure the quality of the product and to lower down the cost of production. Thus inspection can also be termed as a sorting process on the basis of which products can be classified into acceptable or unacceptable.

Inspection is the art of comparing materials, products or performances with established standards. There can be no intelligent inspection without definite standards. In any such items that are to be inspected, some will fall outside a liberal allowance of variation from the standards, some will be well within the limits of error, and others will be very close to the limits. Inspection is the art of selecting these three classes of product which will be satisfactory for the work.

Objectives of inspection: The main objectives or functions of inspection are as follows:

- ***Maintenance of quality:*** The fundamental purpose of inspection is to maintain the quality of the product. This function is performed by comparing materials, semi-finished or finished products, men and machines and tools with the established standards. Items which conform to the specifications or are within the acceptable limits are accepted and other items are rejected.
- ***Improving the product quality***: By comparing the quality of the products against the set standards, the defective items are located and probable reasons for the defects are established. Necessary adjustments are done for future by removing the reasons for defects and thus the quality of the product is improved steadily and regularly. It helps in safeguarding the prestige and confidence of the organisation in the eyes of the consumers.
- ***Reduction in costs:*** As raw materials are inspected to see whether they are as per standards or not the defective raw materials are thus not allowed to be used in production. Thus it saves the organisation from loss if any and reduces the costs of production.

Statistical Quality Control:

Inspection is an integral part of the scheme of production control. By inspection, quality of the product is conformed with the standards and specifications during or at the end of the production process. It is imperative to have certain disturbances which cause the product to deviate slightly from the desired standards. This type of variability is inherent in the process and is known as variability due to chance causes. Causes of deviations like conditions of production process, nature of raw materials, the behaviour of operations etc. Such causes are assignable causes. Due to these causes, defective items are produced which lower the quality of the product.

Inspection has rather a limited use. It does not provide the extent to which certain products requiring a high degree of precision conform to the strict standards set in this regard. Similarly, it does not provide all the information on the basis of which sub-standard finished products can be scrapped in the case of mass production industries, producing standardised products. These imperfections of inspection in quality control make the use of statistical quality control indispensable in these cases.

Statistical quality control is the application of statistical techniques to -determine how far the product conforms to the standards of quality and precision and to what extent its quality deviates; from the standard quality. The purpose of statistical quality control is to discover and correct only those forces which are responsible for variations outside the stable pattern. The standard quality is pre-determined through careful research and investigation.

It is quite impracticable to adhere strictly to the standards of precision, especially in cases where human factor dominates over the machine factor. Some deviation is therefore, allowed or tolerated. They are referred to as tolerances. Within the limits set by these tolerances, the product is considered to be of standard quality. SQC brings to light the deviations outside these limits.

Techniques of statistical quality control. The techniques of statistical quality control can be divided into two major parts:

1. **Control charts, and 2. Acceptance sampling:**

1. ***Control chart:*** Control chart is the most important quality control technique. It is a chart and depicts three lines on the chart. One line is the central line showing the average size. The other two lines, one

below the central line and the other above the central line, indicate the limits of tolerances, within which deviations from standards are permissible. The actual measurement of the whole lot or a sample is plotted on the chart. Those measurement values which fall outside the tolerance limits are considered to be out-of-control points and assignable cause may be said to exist. This will enable die manufacturers to know the causes of variation or causes of trouble which he can amend.

2. ***Acceptance sampling:*** It can be described as the post-mortem of the quality of the product that hasalready been produced. Under this technique, a sample is selected at random to examine whether it conforms to the standards laid down. It can be assumed that a certain percentage of goods will not conform to the standards, so a certain percentage of defective products in a lot may be specified. This technique has all the limitations of sampling technique. There are two limiting levels of quality in an acceptance sampling plan:

   (i) the acceptable quality level (AQL) that represents the lowest percentage of defectives which a buyer is expected to accept and seller is expected to supply, and

   (ii) the lot tolerance percentage defective (LPTD) that represents a limit at which the buyer wants to be quite certain that the lot will not be passed.

The two limiting levels decide the risks to be borne. The AQL involves the producer's risk or the risk that a lot with an acceptable quality will be rejected on the basis of sample inspection. The greater the risk of the producer, the higher will be the charges for the product. On the other hand, risks attached to LPTD are called the consumer's risk. Since only a sample is inspected under the plan, it is quite likely that an item which does not conform to standards may be accepted on the presumption that the sample is typical of the whole lot. The acceptance sampling inspection may be of any of the following types:

(i) Inspection by attributes,

(ii) Inspection by variable, and

(iii) Inspection by number of defects per unit.

Importance or benefits of statistical quality control: The technique of statistical quality control has become very popular since the days of World War II. In modem industry, it becomes a necessity since it offers the following benefits:

- ***It saves on rejection:*** In the absence of statistical quality control technique, many products may be found defective and worthless at the end of manufacturing process and may be thrown away as scrap. SQC avoids such a situation and saves the cost of labour and material involved in the production of defective items. It measures the extent of defect and defective products may be improved by re-working to the level of acceptable standards. It also saves the loss which will arise out of re-working on the items rejected outrightly or which cannot be brought to the acceptable standard.

- ***It maintains, high standard of quality:*** The statistical quality control ensures the maintenance of high standard of quality because lower standard of quality products are not put to the market. They are improved, if possible or rejected outrightly but in no case, sub-standard item is sold in the market. Thus, the concern gains in goodwill.

- ***Reduced expenses of inspection:*** It reduced the expenses of inspection to a great extent and enables the product to be manufactured at lower cost.

- ***Ensures standard price:*** If certain products are not up to the desired standard of quality and cannot be improved without much expense, they can be downgraded and sold cheaper. SQC maintains the standard price for all standard products. Thus, it increases the profitability of the concern.

- ***Feelings of responsibility among workers:*** Among workers, a feeling of responsibility develops because they begin to understand that their work is being inspected very minutely hence they work carefully. It helps increasing their moral.

Benefits of SQC:

(i) It saves on rejection
(ii) It maintains high standard of quality
(iii) It reduces expenses of inspection
(iv) It ensures standard price for all products
(v) Feelings of responsibility among workers development

Control Charts:

The concept of control charts and their application in production process was evolved for the first time in 1924. This concept is based on the division of observations in rational sub-groups. The sub-groups are formed in such a way that the variation within each sub-group is attributable due to chance causes only and variation between the sub-groups are attributed due to assignable causes. The most obvious basis for the selection of sub-group is the order of production. The problem of process control can be solved by applying a method which helps in finding out the quality characteristics of various sub-groups. If the quality characteristics of various sub-groups are identical, the process is said to be in control otherwise out $\bar{X}$
of control.

Statistical basis for control charts: Suppose Q is the quality characteristic of a product. This characteristic should be measured for a number of sub-groups. If Q follows some standard distribution (Normal, Poisson or Binomial) with mean MQ and standard deviation óQ. If the sample size is sufficiently large then every distribution will be normal and due to the assumption of normality the interval $MQ \pm 3\sigma Q$ will cover approximately 99.73% values of Q. If all the observed values of Q lie within the limits $MQ+3\sigma Q$, this may be taken as the indication of absence of assignable cause. If any value of Q lies outside the limits, the presence of assignable cause can be presumed and the process should be corrected before it is allowed to continue.

The control chart is a horizontal chart where time variable is taken on X-axis. A control line (CL) is drawn along the X-axis at MQ point. Time for two other limits, lower control limits LCL ($MQ-3\sigma Q$) and upper control limit UCL ($MQ+3\sigma Q$) are drawn taking the CL in the centre. The values of quality characteristics Q are also plotted on group for different observations from sample to sample or according to time variables.

The following observations can be had from the control chart.

(i) If all the plotted points for Q lie within the control limits, the process is said to be in control otherwise it can be said to be out of control with respect to the quality characteristic Q.

(ii) If the points on a control chart lie close to one of the control lines or the points show some special trend, then it is very difficult to pay anything about the process control. A typical control chart can be drawn in the following figure—

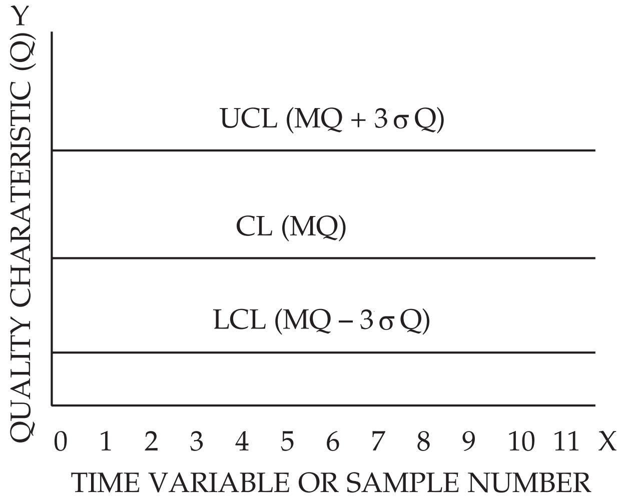


FIG. CONTROL LIMITS

Thus control chart is a graph showing the range of expected variability. The following points should be considered while drawing a control chart.

(i) If two comparable control charts are to be drawn on the same paper, it is better to take the same scale for both the charts.

(ii) The charts should be narrow in comparison to their length.

$\bar{X}$

(iii) So many charts should be avoided on the same sheet.

Types of Control Charts: Control charts are of two types: (i) control chart for variables, and (ii) control chart for attributes.

If the quality characteristic Q is capable of quantitative measurement, the control chart is known as control chart for variables and if the quality characteristic Q cannot be measured quantitatively the control chart is known as control chart for attributes. The items can only be classified as defective or non-defective etc.

1. C***ontrol Chart for Variables.*** In this case, quality characteristic Q is capable of direct quantitative measurement and is a continuous variable. In such cases the average and the standard deviation of the quality characteristic can be calculated from a number of samples each having fixed number of components, taken at random over a period of time from any process. The following situations can be encountered in practice:

(i) The process may be in control.

(ii) The mean of the characteristic is out of control but standard deviation is not. For this purpose, control chart for means (X-chart) are prepared.

(iii) The standard deviation is out of control and not the mean. This is studied by control chart for range (R-chart). Here range is the measure of variability because it can be easily determined.

(iv) Both mean and standard deviation are out of control. This is studied by X and R charts simultaneously.

(A) Control chart for mean ($\bar{X}$-chart):

By this chart, it is found whether the mean of the characteristic can be determined by the following formula:

$$\text{Central line} = \bar{\bar{X}} = \frac{\sum \bar{X}}{K}$$

Where $\bar{\bar{X}}$ = Mean of the sample means

$\Sigma \bar{X}$ = Sum of the sample means

K = No. of samples.

By this method lower control limit (LCL) and upper control limit (UCL) are determined as follows:

(i) Where standard deviation is known –

$$UCL = \bar{\bar{X}} + \frac{3\sigma P}{\sqrt{N}} + \text{ and } LCL = \bar{\bar{X}} - \frac{3\sigma P}{\sqrt{N}}$$

where UCL = upper control limit

LCL = lower control limit

$\bar{\bar{X}}$ = mean of the sample means

σP = standard deviation of population

N = total number of items in a sample.

(ii) Where standard deviation is not given –

The standard deviation can be determined by the following formula:

$$\sigma P = \frac{\bar{R}}{d_2}$$

Where $\bar{R}$ = mean of sample range

d_2 = quality control factor.

(iii) Where d_2 is not given, then

$$UCL = \bar{\bar{X}} + A_2\bar{R}$$

$$LCL = \bar{\bar{X}} - A_2\bar{R}$$

where A_2 = quality control factor.

(B) **Control chart for range or range chart** (R-chart). This chart is used to see whether the standard deviation of the characteristic Q is in control or not. Here can be two situations, viz, (i) where σP is known. (ii) where σP is unknown.

(i) Where σP is known. In this case central line (CL) and upper and lower limits can be determined as follows:

Range (R) = Highest value – lowest value

$$\text{Mean of R or } \bar{R} = \frac{\sum R}{K}$$

Central line = $\bar{R} = d_2 \sigma P$ where K = total no. of samples.

$UCL = d_2 \sigma P + 3 \sigma P . d_3$

$LCL = d_2 \sigma P - 3 \sigma P d_3$

Where d_2 and d_3 can be determined from statistical tables.

(ii) Where σP is unknown

$$CL = \bar{R} = \frac{\sum R}{K} = \frac{\text{Sum of sample range}}{\text{No. of Samples}}$$

$$UCL = D_4 \bar{R}$$

$$LCL = D_3 \bar{R}$$

Where D_3 and D_4 can be read from the statistical table for control charts. As a rule if LCL is negative, it is taken to be zero.

Practical limitations of $\bar{X}$ and R-charts: X and R charts are very important tools for the diagnosis of quality problems in a manufacturing process but they have the following practical limitations:

1. These charts can be used where quality characteristic can be measured quantitatively.
2. Quantitative measurement of quality characteristic is a costly proposition, hence its use is uneconomical

Interpretation of $\bar{X}$ and R-charts. $\bar{X}$ and R-chart can be used simultaneously to judge the quality of the process as follows:

(i) Where R - chart shows all the points within control limits:

  (a) If in $\bar{X}$ - chart, the points lie beyond one of the control limits, it shows that process level has shifted.

  (b) If in $\bar{X}$ - chart, the points lie beyond both of the control limits, it shows that the process level is changing at random and needs frequent adjustment.

(ii) Where R-chart shows variability out of control:

  (a) If $\bar{X}$ - chart shows points beyond one of the control limits, it signifies that both process level and variability have changed.

  (b) If $\bar{X}$ -chart shows points beyond both of the control limits, then this implies that variability has increased.

(iii) If points in $\bar{X}$ and R-charts are too close to the central line, then it shows that there exist systematic difference within sub-groups.

2. ***Control chart for attributes:*** Where the nature of product is such that the quality characteristic cannot be measured quantitatively, the items are classified only defectives and non-defectives at the time of final inspection.

   There can be a number of factors responsible for defining any item to be defective and the separate record for each cause maybe out of question. The defects can be measured in airy of the following two ways:

   (i) Number of defective items are taken in different samples. Here $\bar{p}$ or n$\bar{p}$ charts is used.

   (ii) Number of defects in one item. In this case $\bar{C}$ chart is used.

Control chart for fraction defectives ($\bar{p}$ or n $\bar{p}$ charts)

These charts are constructed by recording at least 20 successive inspections. The percentage of defective items is then calculated. The limits for P-chart are given by:

$$\text{CL or } \bar{P} = \frac{\sum P}{n \times k}$$

$$\text{UCL or upper control limit} = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}}$$

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

Here $\bar{P}$ = central line

P = No. of defective items in a sample

K = Total no. of samples

n = Sample size (no. of items in a sample),

nP chart = In situations where the number of items inspected in each sample is the same, nP charts are prepared. The various control limits in this case are

$$CL = n\bar{P} = \frac{\sum P}{K}$$

$$UCL = n\bar{P} + 3\sqrt{P(1-\bar{P})}$$

$$LCL = n\bar{P} - 3\sqrt{nP(1-\bar{P})}$$

P and *nP* charts can be used in the case of variables also.

C-charts. C = charts are prepared where defective items are taken out by the number of defects in one item. Items which are according to specifications are termed as standard items. Items which have one or more defects, it means they do not fulfils one or more of the given specifications. All defects are not of the same value. So, we may like to control defects per unit. The quality characteristic in such cases is the number of defects per unit. C-chart is just an improvement over P-chart. C-chart follows Poisson distribution and various limits are calculated as follows:

Central line = $\bar{C} = \frac{\text{Total defects}}{\text{Total No. of items inspected}}$

Upper control limit (UCL) = $\bar{C} + 3\bar{C}$

Lower control limit (LCL) = $\bar{C} - 3\bar{C}$

Problems and Solutions

Problem 1 :

Draw the control charts for $\overline{X}$ (mean) and R (Range) from the following data relating to 20 samples, each of size 5. Only the control line and the upper and lower control limits may be drawn in each chart.

Sample No.	$\overline{X}$	R	Sample No.	$\overline{X}$	R
1	38.2	15	11	32.6	31
2	33.8	1	12	22.8	12
3	24.4	22	13	21.6	29
4	36.6	24	14	28.8	22
5	27.4	18	15	28.8	16
6	30.6	33	16	24.4	19
7	31.2	21	17	30.4	20
8	27.0	29	18	25.4	34
9	24.0	29	19	37.8	19
10	29.4	18	20	31.4	17

(For sample of size 5-d_2 = 2.326, d_3 = 0.864)

Solution: (1)

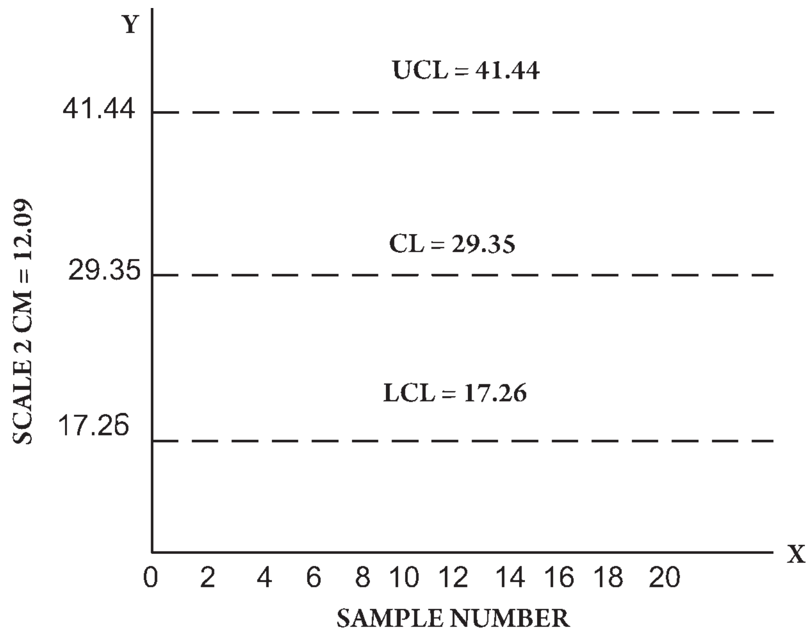
$\overline{X}$ -chart (mean chart)

Here $\sum \overline{X} = 587$ $\sum R = 420$ K = 20 N = 5

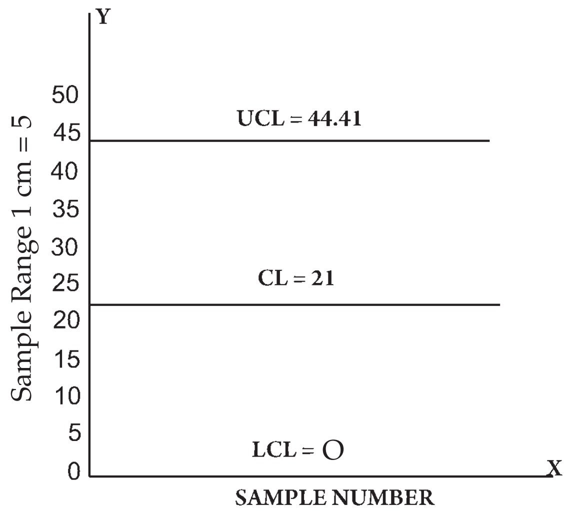
$$\text{CL or } \overline{\overline{X}} : \frac{\sum \overline{X}}{\text{K or No. of samples}}$$

$$\text{UCL} = \overline{\overline{X}} + \frac{\frac{3\overline{R}}{d_2}}{\sqrt{N}} = 29.35 + 3 \times \frac{\frac{2}{2.326}}{\sqrt{5}} = 29.35 + \frac{27.09}{2.24} = 29.35 + 12.09 = 41.44$$

$$\text{LCL} = \overline{\overline{X}} - \frac{\frac{3\overline{R}}{d_2}}{\sqrt{N}} = 29.35 - \frac{27.09}{2.24} = 29.35 - 12.09 = 17.26$$



(2) R-Chart



CL or $\overline{R} = \frac{\sum R}{K} = \frac{420}{20} = 21$

UCL = $\overline{R} + 3\sigma R^* = 21 + (3 \times 7.802) = 21 + 23.41 = 44.41$

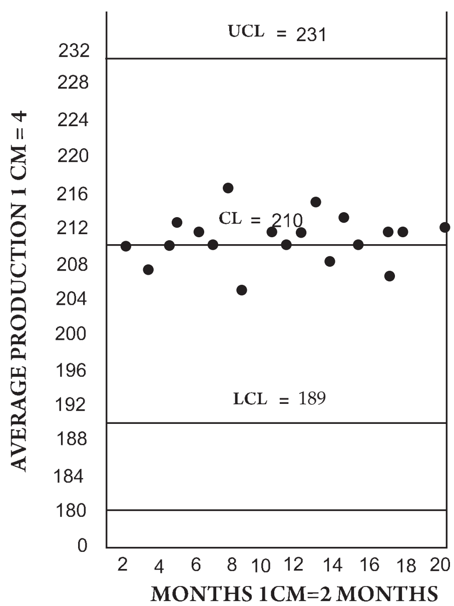
LCL = $\overline{R} - 3\sigma R = 21 - (3 \times 7.802) = 21 - (3 \times 7.802) = 21 - 23.41 = -2.41$ or zero

$^*\sigma R = \sigma P \times d_3$, or $\frac{\overline{R}}{d_2} \times d_3 = \frac{21}{2.326} \times .864 = 9.03 \times 0.864 = 7.802$

Problem: 2

The following table gives the average daily production figure for 20 months each of25 working days. Given that the population standard deviation of daily production is 35 units, draw a control chart for the mean.

210	205	210	212	211	209	219	204	212	209
212	215	208	214	210	204	211	211	203	211



Solution:

$\bar{X}$ -chart

Conclusion:

All the points lie within the control limits. The process is well within control.

$$CL \text{ or } \bar{\bar{X}} = \frac{\sum \bar{X}}{K} = \frac{4200}{20} = 210$$

$$UCL = \bar{\bar{X}} + \frac{3\sigma P}{\sqrt{N}} = 210 + \frac{3\times 35}{\sqrt{25}} = 210 + \frac{105}{5} = 231$$

$$LCL = \bar{\bar{X}} - \frac{3\sigma P}{\sqrt{N}} = 210 - \frac{3\times 35}{\sqrt{25}} = 210 - \frac{105}{5} \text{ or } 210 - 21 = 189$$

Problem 3:

15 Samples of size 4 each were taken and the observed values are given below:

Samples		Observed values		
1	32	20	33	6
2	42	36	52	50
3	25	15	52	63
4	22	33	34	23
5	29	30	27	31
6	30	34	26	16
7	34	31	28	34
8	11	21	20	16
9	11	22	28	31
10	36	30	35	26
11	34	16	37	26
12	27	36	51	53
13	26	35	32	37
14	25	36	37	24
15	10	28	14	13

Calculate UCL and LCL for $\bar{X}$ Chart and R chart. Also prepare the chart on graph paper. For a sample size 4 the control factors are —

$A_2 = 0.729$, $d_2 = 2.059$, $d_3 = 0.880$, $d_4 = 2.282$.

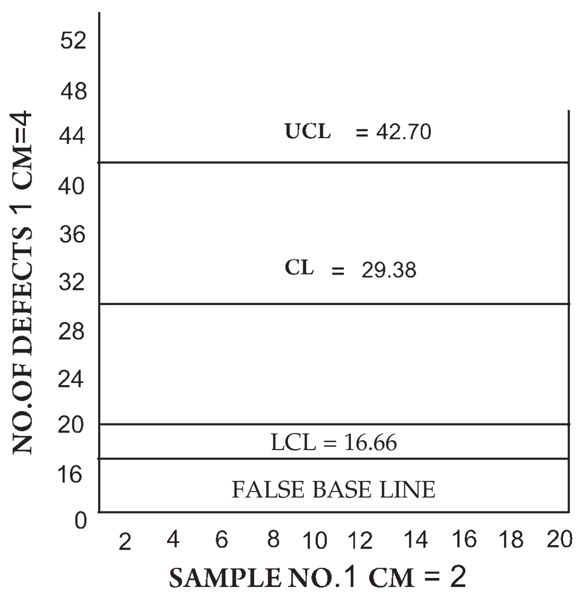
Solution:

Samples		Observed Values			$\bar{X}$ or Mean	R (Higest = Lowest)
1	32	20	33	06	91/4 = 22.75	33 -6 = 27
2	42	36	52	50	180/4 = 45.00	52 -36 = 16
3	25	15	52	63	155/4 = 38.75	63 - 15 = 48
4	22	33	34	23	112/4 = 28.00	34 - 22 = 12
5	29	30	27	31	126/4 = 31.50	39 - 27 = 12
6	30	34	26	16	106/4 = 26.50	34 - 16 = 18
7	34	31	28	34	127/4 = 31.75	34 - 28 =06
8	11	21	20	16	68/4 =17.00	21 - 11 = 10
9	11	22	28	31	92/4 = 23.00	31 - 11 = 20
10	36	30	35	26	127/4 = 31.75	36 - 26 = 10
11	34	16	37	26	113/4 = 28.25	37 - 16 = 21
12	27	36	51	53	167/4 = 41.75	53 - 27 = 26
13	26	35	32	37	130/4 = 32.50	37 - 26 = 11
14	25	36	37	24	122/4 = 30.50	37 - 24 = 13
15	10	28	14	13	65/4 = 16.25	28 - 10 = 18

X - Chart-

$$\text{CL} = \frac{\sum \bar{X}}{\text{K or No.of samples}} = \frac{445.25}{15} = 29.68$$

$$\text{UCL} = \bar{X} + A_2 \bar{R} = 29.68 + (0.729 \times 17.867) = 29.68 + 13.02 = 42.70$$



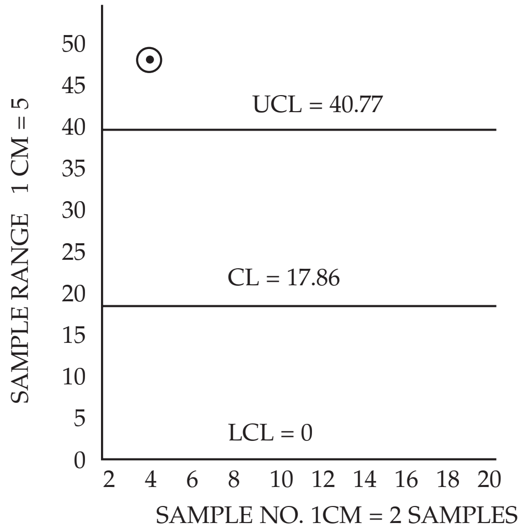
Conclusion: Sample no. 2 is outside UCL and sample no. 15 is outside LCL.

LCL = $\bar{\bar{X}} - A_2\bar{R}$ =29.68 – (0.729 x 17.867) = 16.66

R-chart –

CL or $\bar{R} = \dfrac{\sum R}{\text{K or No. of samples}} = \dfrac{268}{15} = 17.867$

UCL = $d_4 \times R$ = 2.282 × 17.867 = 40.77



LCL = $d_3 \times \bar{R}$ = 0 × 17.867 = 0

Conclusion : Sample 3 is outside control limits.

Problem: 4

The following table gives the result of inspection of 20 samples of 100 items each taken in 20 working days. Draw a P-chart. What conclusion do you draw from the chart about the process?

Sample number	No. of defectives	Sample number	No. of defectives
1	6	11	10
2	2	12	4
3	4	13	6
4	1	14	11
5	20	15	22
6	6	16	8
7	10	17	0
8	19	18	3
9	4	19	23
10	21	20	10

Solution:

Total No. of items inspected = No. of samples × units inspected in each sample

= 20 × 100 =2000 units

Average fraction defectives = $\dfrac{\text{Total no.of defectives}}{\text{Total no. of items inspected}} = \dfrac{200}{2000} = 0.10$

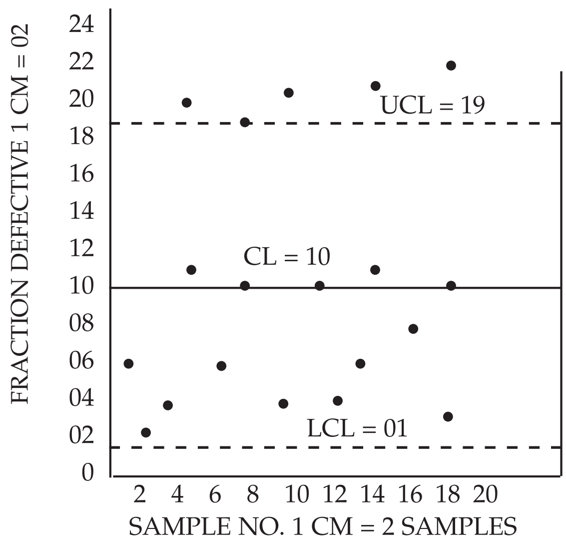
$\bar{P}$ or CL =0.10

UCL = $\bar{P} + \sqrt{\left(\dfrac{\bar{P}(1-\bar{P})}{n}\right)} = 0.10 + 3\sqrt{\left(\dfrac{0.10(1-0.10)}{100}\right)} = 0.10 + 3\sqrt{0.0009}$

= 0.10 + 3 × 0.03 = 0.10 + 0.09 = 0.19

LCL = $\bar{P} - \sqrt{\left(\dfrac{\bar{P}(1-\bar{P})}{n}\right)} = 0.10 - 3\sqrt{\left(\dfrac{0.10(1-0.10)}{100}\right)} = 0.10 + 3\sqrt{0.0009}$

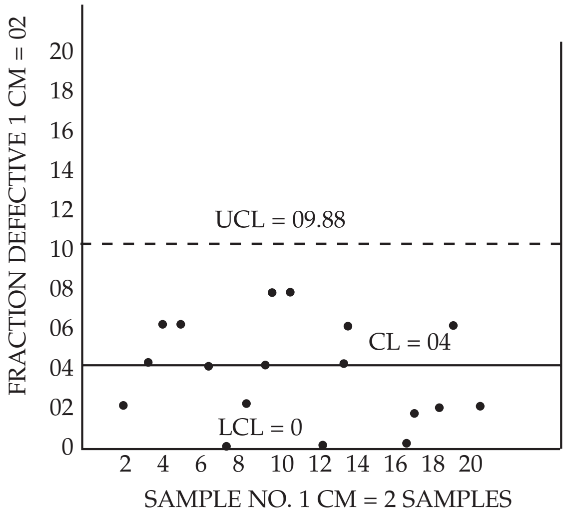
= 0.10 – 3 × 0.03 = 0.10 – 0.09 = 0.01



Conclusion: Four points, i.e., sample numbers 5, 10, 15 and 19 lie outside the control limits.

Problem: 5

The following table gives the result of inspection of 20 samples of 100 items each taken on 20 working days. Draw a P-chart. What conclusion would you draw from the chart?



Conclusion: Only sample number 15 is beyond control limits.

Sample No.	1	2	3	4	5	6	7	8	9	10
No. of defectives	9	17	8	7	12	5	11	16	14	15
Sample No.	11	12	13	14	15	16	17	18	19	20
No. of defectives	10	6	7	18	16	10	5	14	7	13

Solution:

Total no. of items inspected = No. of samples × units inspected in each sample

= 20 × 100 = 2000 units.

Average fraction detectives or $\bar{P} = \dfrac{\text{Total no. of defectives}}{\text{Total no. items inspected}} = \dfrac{80}{2000} = 0.04$

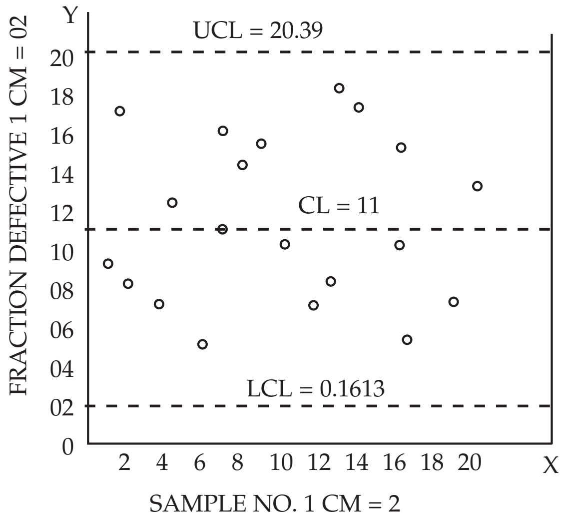
Hence $\bar{p}$ or CL= 0.04

$$\text{UCL} = \bar{P} + 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}} = 0.04 + 3\sqrt{\frac{.04(1-.04)}{100}} = 0.04 + 3\sqrt{0.000384} = 0.04 + 3 \times 0.0196 = 0.04 + 0.0588 = .0988$$

$$\text{LCL} = \bar{P} - 3\sqrt{\frac{\bar{P}(1-\bar{P})}{n}} = 0.04 - 3\sqrt{\frac{.04(1-.04)}{100}} = 0.04 - 3\sqrt{0.000384} = 0.04 - 3 \times .0196 = 0.04 - 0.0588 = -0.0188 = 0$$

Problem: 6

The following table gives the result of inspection of 20 samples of 100 items each taken on working days. Draw a P-chart. What conclusion would you draw from the chart?



Conclusion : No. point is beyond limit

Sample No.	1	2	3	4	5	6	7	8	9	10
No. of Defectives	0	2	4	6	6	4	0	2	4	8
Sample No.	11	12	13	14	15	16	17	18	19	20
No. of Defectives	8	0	4	6	14	0	2	2	6	2

Solution:

Total number of items inspected = No. of samples × units in each sample

= 20 ×100 = 2000 units

Average traction defectives or $\bar{P} = \dfrac{\text{Total no. of defectives}}{\text{Total no. items inspected}} = \dfrac{220}{2000} = 0.11$

(i) CL = 0.11

(ii) UCL = $\bar{P} + 3\sqrt{\dfrac{\bar{P}(1-\bar{P})}{n}} = 0.11 + 3\sqrt{\dfrac{.11(1-.11)}{100}} = 0.11 + 3\sqrt{\left(\dfrac{.0979}{100}\right)}$

= 0.11 + 3 × 0.03129 = 0.11 + 0.09387 = 0.20387 = 0.2039

(iii) LCL = $\bar{P} - 3\sqrt{\dfrac{\bar{P}(1-\bar{P})}{n}}$ - 3 = 0.11 - 3 × 0.03129 = 0.11-0.09387 = 0.01613

Problem 7. 18 carpets had defects in their finish as follows. Supposing the defects follow the Poisson Law. draw a control chart for the number of defects.

No. of Defects	0	1	2	3	4	5	6
No. of carpets having specified No. of Defects	0	1	2	4	3	5	3

Solution.

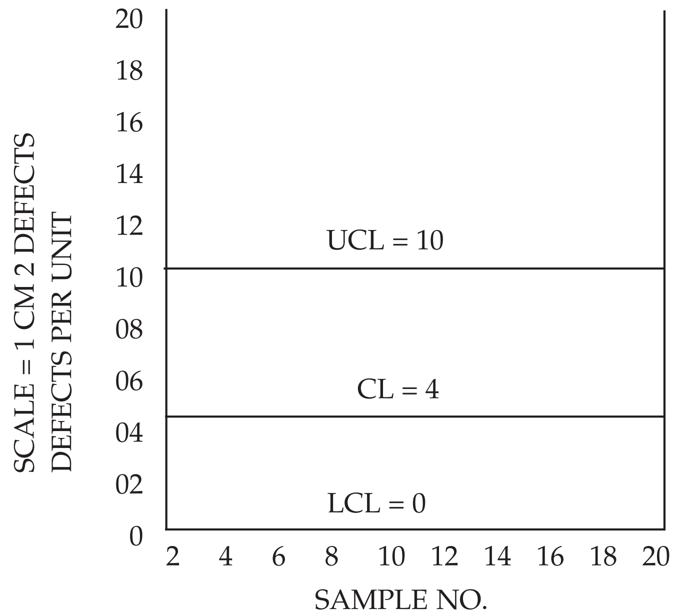
$$\bar{C} = \frac{\text{Total no. of defectives}}{\text{Total no. of carpets examined}}$$

$$= \frac{(0\times0)+(1\times1)+(2\times2)+(3\times4)+(4\times3)+(5\times5)+(6\times3)}{(0+1+2+4+3+5+3)}$$

$$= \frac{0+1+4+12+12+25+18}{18} \text{ or } \frac{72}{18} = 4 \quad \therefore \text{CL} = \bar{C} = 4$$

$$\text{UCL} = \bar{C} + 3\left(\sqrt{\bar{C}}\right) = 4 + 3\sqrt{4} \text{ or } 4 + 3 \times 2 = 4 + 6 = 10$$

$$\text{LCL} = \bar{C} - 3\left(\sqrt{\bar{C}}\right) = 4 - 3\left(\sqrt{4}\right) \text{ or } 4 - 3 \times 2 = -2 = 0$$



Problem: 8

In the following example —

E	A	B	C	D	F
	0.600 ±	0.750 + 0.002	1.250 ± 0.003	0.700 ± 0.001	

Parts A, B, C and D must fit within the space EF. What should be the dimension and tolerance of EF?

Solution:

The typical engineering approach is as follows:

Part	Nominal Dimension (cm)	Total Tolerance (cm)
A	0.600	0.002
B	0.750	0.004
C	1.250	0.006
D	0.700	0.002
Total	3.300cm	0.014cm

The tolerance would be half the total tolerance of 0.014 or 0.007 cm., and the dimension specification would be 3.3000 ± 0.007.

One statistical approach uses the formula

$$T_t = \sqrt{T_1^2 + T_2^2 + \dots\dots\dots + T_n^2}$$

in which T is the individual tolerance and T_t is the total tolerance. Using this concept, the tolerance for the example would be:

$$T_t = \sqrt{(0.002)^2 + (0.004)^2 + (0.005)^2 + (0.002)^2} = 0.00775 \text{ or } 0.008$$

The dimension specification would then be expressed as 3.300 ± 0.004 cm. with a total tolerance of 0.008 cm.

It would be noted that the statistical tolerance of 0.008 is approximately 55% of the conventional tolerance of 0.014 cm. Now if the EF dimensions were as much as 0.014 cm or even 0.010 cm. one or several of the parts tolerance can be widened and still be within good practice.

Problem: 9

Incoming steel to be used in processing is tested to see that it is of the right chemical composition before it is machined. Dimensions of the machined parts are inspected, prior to the heat treating operation. An automatic heat treatment furnace is set at a temperature which hardens the parts. The temperature is set so that the average force required to break the part is 32000 unit wt. The inherent variability of the heat treating process produces a standard deviation of the breaking force at 3000 unit wt. Establish the control limits for $\overline{x}$ so that α = 0.10 when sample of size n = 4 are taken.

Solution:

$$\sigma = \frac{\sigma}{\sqrt{n}} = \frac{3000}{\sqrt{4}} = 1500 \text{ Unit-wt.}$$

$$Z(1-\frac{\alpha}{2}) = 1.645$$

UCL $\overline{x}$ = $\mu + Z\sigma\,\overline{x}$ = 32000 + 1.645(1500) = 34467.5 unit-wt.

UCL $\overline{x}$ = $\mu - Z\sigma\,\overline{x}$ = 32000 - 1.645(1500) = 29532.5 unit-wt.

Problem: 10

The radiology department of a large hospital has an average retake rate of 8.8%; i.e. 8.80% of its x-rays must be repeated because the picture is not sufficiently clear. Errors can occur because of incorrect patient measurement, improper calibration or setting of the machine, poor film quality, incorrect film processing or other reasons. During the past month, 9000 x-rays were taken, and 11.2% had to be repeated. Does the process appear to be within its 3σ limits or does it appear that there may be some assignable cause for variation?

Solution:

$\overline{p}$ = 0.088

Control limits for p when a sample of 9000 is taken are:

$$\overline{p} \pm \sqrt[3]{\frac{(1-\overline{p})}{9000}} = 0.088 \pm \sqrt[3]{\frac{0.088(1-0.088)}{9000}} = 0.09070 \text{ and } 0.0790$$

The value of 11.2% defective is very much outside the 3σ limits for the process.

Problem: 11

Twenty samples were taken from a cable-weaving machine while it is being operated under closely controlled conditions. The number of defects per 100 meters for the samples is recorded in the chart below. Determine the control chart limits for the machine.

4	4	5	3
6	2	2	4
5	3	4	2
3	2	4	5
5	7	5	3

Solution:

$$z = \frac{\sum c}{n} = \frac{78}{20} = 3.9$$

Control limits for the number of defects per 100 meters are: $\overline{c} \pm 3\sqrt{c}$

UCL = $3.9 + 3\sqrt{3.9} = 9.8$

LCL = $3.9 - 3\sqrt{3.9}$ = negative or, 0, whichever is greater.

Therefore LCL = 0

Problem: 12

An attribute control chart exists for part 3146B shows the average fraction defective 0.125, upper control limit 0.200 and lower control limit 0.050, based on two months of daily data. Recently, 12 units were sampled each day for six days with units defective 2, 1, 2, 0, 3 & 3.

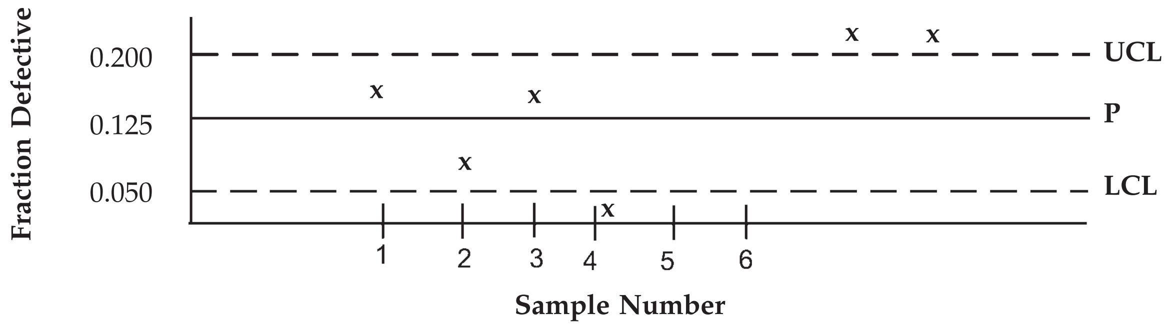
(a) Construct a control chart for management, carefully labelling the chart, and interpret it for management.

(b) What is the significance of the fraction defective for day 4 being below the lower control limit?

Solution:

The solution for part (a) is shown in the following figure. Fraction defective for the recent six days are:

2/12 = 0.166	1/12 = 0.083	2/12 = 0.166
0/12 = 0	3/12 = 0.250	3/12 = 0.250



(b) The control limits should be set in such a way that measurements falling outside the limits are regarded as a warning signal. The lower control limits for fraction defective is useful because some change in methods, equipment or people has resulted in improved quality. The cause should be found out.

STUDY NOTE - 3

Maintenance Management

3.0 Obsolescence, Replacement of Machinery

Wear and obsolescence are the two main causes for replacement of machinery in every aspect of life. The reduction of wear is therefore a primary concern when designing appliances. Wear and tear due to passage of time and/or normal usage of plant and machinery is an accepted fact. Technological obsolescence is a major danger which business firms face in modern era. With the development of new and better techniques or equipment of performing a particular function, existing equipment and machines become uneconomical. Whenever a firm decides to switch over to new machines or improved product designs, existing machine designs are said to be obsolete. Hence, obsolescence is a major issue in the procurement and installation of machinery and equipment. A machine is technically obsolete when another machine can do the same job more efficiently, with reduced time and also at a lower cost. Technological obsolescence arises due to continuous improvements in the methods and techniques of production and sometime the rate of improvement is so fast that it becomes economical to replace the machinery before its expected life. A machine may be replaced to reduce the running costs of the concerned machine and the new machines productivity will be more. In replacement decisions, the basic problem is to decide whether to replace a machine or equipment at present or at a future date. It is, therefore, necessary to determine whether obsolescence or deterioration has reached the point where the reduction in operating costs expected from replacement justifies the net capital expenditure involved in installing the new machine and disposing of the old one.

Any function aimed at brining back or restore an item to its original or acceptable position or to keep it and retain its healthy, workable position is known as Maintenance.

Objectives of Maintenance:

The objectives of maintenance are : (i) To keep all the production facilities and other allied facilities such as building and premises, power supply system, etc in an optimum working condition, (ii) To ensure specified accuracy to products and time schedule of delivery to customers, (iii) To keep the down time of the machine at minimum, so that the production program is not disturbed, (iv) To keep the production cycle with in the stipulated range, (v) To modify the machine tools to meet the augmented need for production, (vi) To improve productivity of existing machine tools and to avoid sinking of additional capital, (vii) To keep the maintenance cost at a minimum as far as possible, there by keeping the factory Overheads at minimum, (viii) To extend the useful life of plant and machinery, without sacrificing the level of performance.

3.1 Break Down Maintenance, Preventive Maintenance, Routine Maintenance – Break down maintenance

Here the production facility is run without much routine maintenance until it breakdown. Once the machine breakdown it is taken for repair and inspected to find out the defects. After identifying the defect, the required repair is planned and the spares are procured to repair the machine. As the breakdowns are random in nature and the machine cannot be used during the repair period, production hours are lost hence the productivity is reduced. Repair maintenance is not a recommended practice, in general, but many a time many organizations prefer this, because they do not want to keep the machine idle for maintenance. But they ignore the fact that the break down repair costs more than the regular maintenance practice. It is however, an economical way of maintaining certain non-critical items whose repair and down time costs are less this way than with any other system of maintenance.

PREVENTIVE MAINTENANCE:

A system of scheduled, planned or preventive maintenance tries to minimize the problems of breakdown maintenance. It locates weak parts in all equipments, provides them regular inspection and minor repairs thereby reducing the danger of unanticipated breakdowns. The underlying principle of preventive maintenance is that prevention is better than cure. It involves periodic inspection of equipment and machinery to uncover conditions that lead to production breakdown and harmful depreciation. The system of preventive maintenance varies from plant to plant depending on the requirement of the plant. Any company, adopting the preventive maintenance should keep the record of failure of various components and equipment, which help the maintenance department to statistically analyze the failure pattern and replace the item before it fails, so that the breakdown can be eliminated. This reduces the unanticipated breakdowns, increases the availability of the equipment, maintain optimum productive efficiency of equipment and machinery reduces the work content of maintenance job, increases productivity and safety of life of worker.

Production department or maintenance department depending on the size of the plant generally takes up preventive maintenance work. As the preventive maintenance is a costly affair, it is better to maintain records of cost (both labour, materials used and spares used) and a valuation of the work done by the department will show us what benefits are derived from preventive maintenance. The analytical approach to evaluate the work done by preventive maintenance is

(i) (Inspections incomplete) / (Inspections scheduled) × 100 should be less than 10%

(ii) (Hours worked for maintenance) / (Scheduled hours) × 100 = Performance of the department.

(iii) Down time to be given as a ratio of the available hours and to be compared against a standard to be worked out for each company or against a figure of the past. The ratio is given as:

= Down time in hours/ Available hours = working days × hours per day × number of machines. Here down time is the total time of stoppage of the machine for scheduled and unscheduled maintenance work.

(iv) Frequency of break downs = (Number of break downs) / (Available machine hours)

(v) Effectiveness of planning = (Labour hours on scheduled maintenance) / (Total labour hours spent on maintenance).

OR

(Down time due to scheduled maintenance)/(Down time due to total maintenance work)

Advantages of preventive maintenance are (i) Reduced breakdowns and downtime, (ii) Greater safety to workers, (iii) Fewer large scale repairs, (iv) Less standby or reserve equipment or spares, (v) Lower unit cost of the product manufactured, (vi) Better product quality, (vii) increased equipments life and (viii) Better industrial relations.

Routine Maintenance:

It includes lubrication, cleaning, periodic overhaul; etc. This is done while the equipment is running or during pre-planned shut-downs. Running maintenance is the work which can be carried out while the facility is in service.

3.2 Maintenance Techniques

It can be discussed as under:

In some cases the loss and inconvenience due to breakdown of equipment is so high that standby equipment is kept. As soon as the original equipment fails, the standby facility is employed to avoid interruption and downtime. Standby machines are often kept to reduce the loss due to the breakdown of a key machine. Breakdown maintenance also requires use of standby machines. The main question here is how many standby machines to keep and for how long. In order to decide this, a cost benefit analysis of standby machines should be made. There are various costs involved in standby machines. First, there is interest cost on capital investment. Secondly, space is needed to keep standby machines. Thirdly, there is depreciation in the value of standby machines. Fourthly, periodic checking and servicing is necessary to keep the standby machines in new condition. The benefits of standby machines consist of protection against a complete shutdown or shut down of operations. It avoids loss of production and, therefore, it is necessary to estimate loss of future failures a table of expected costs and benefits can be prepared.

Shifting production during breakdown. Under this method spare capacity is maintained not in the form of standby machines but by allowing rest to running machines at intervals and by rotation. If one machine in a production line requires shutdown, the output is maintained by shifting to under uitilised machines in other lines. For such application, the capacities of different machines must be properly matched.

3.3 Maintenance Organization

At least 50 to 60 percent of investment of any organization is spent on Building and Production facilities. Hence, it is worthwhile to give due consideration for effective maintenance of these items. The maintenance department will looks after the upkeep of equipments, buildings and other. For effective contribution of its work, the maintenance department must have proper place in the organization and it must also have a good organizational structure. While organizing a maintenance department one must remember that there should be clear division of authority with little or no overlap. Vertical lines of authority and responsibility must be kept as short as possible. Keep the span of control to an extent of 3 to 6 for a manager. The organizational structure should be flexible. The structure should be designed to suit the types of maintenance work involved. Depending on the need, the maintenance activity may be centralized or decentralized.

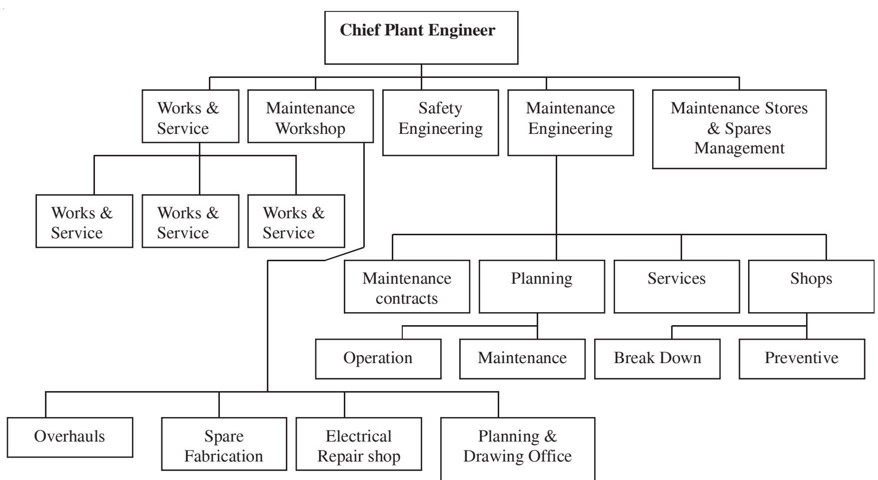


Figure. Outline of a maintenance department of a large company

Organizing Maintenance Work

In order to facilitate proper control of maintenance work; we must enforce three rules as below.

Maintenance Request

This must be made in writing to a central point in the organization. No work should be carried out without the knowledge and approval of maintenance supervision - if this discipline is not followed by the organization, it leads to wastage of skilled manpower and inability of the maintenance personnel to schedule essential maintenance work.

Maintenance Stores

Non-availability of vital spare parts when required to meet an emergency like breakdown, may lead to excessive shutdown of the plant and equipment. A large number of items or materials are required to be stored and it involves investing valuable funds from the working capital. A proper stores management is essential as a backup service of good maintenance.

Records of Maintenance Work Done

Paper work for maintenance is crucial for establishing a good maintenance organization and is often neglected. The records of maintenance work carried out from time to time have to be kept equipment wise. History cards or logbooks of all the plants and equipment must be compiled meticulously giving details of materials used, components replaced and time spent by the workforce.

Creation and maintaining this database is essential for proper planning and control, which alone will lead to effective and efficient maintenance.

To get the full benefits of effective maintenance the following requirement is to be fulfilled:

(i) Good Supervision and administration of maintenance department, (ii) Good and clear instructions to be given to maintenance crew regarding the repair, (iii) Proper control of work in coordination with production department, (iv) Good training should be given to the maintenance personnel, (v) Good scheduled maintenance program should be chalked out, (vi) Proper maintenance record keeping is a must, (vii) There should be adequate stock of spare parts, particularly insurance spares.

3.4 Maintenance Problem

The main problem in maintenance analysis is to minimise the overall cost of maintenance without sacrificing the objectives. There are two alternatives before management. One is to repair a machine or equipment only when it breaks down. This will save expense of inspection and replacement of a part before its lifetime ends. The other alternative is to replace the equipment before the expiry of its working life. This will involve cost of periodic shutdown for check up and repairs. However, it will avoid the loss due to sudden failure or breakdown.

The two types of cost - cost of premature replacement and cost of breakdown - need to be balanced. The objective is to minimise total maintenance cost and downtime. Economic analysis is helpful in finding a judicious combination of two types of maintenance. The relationship between preventive maintenance time and repair time is also significant. Preventive maintenance policy is justified only when the average downtime and its cost is less than the average time taken to carry out breakdown repairs. If the machine happens to be part of production line, the breakdown of a machine would throw the entire production line out of gear while a preventive maintenance schedule might enable the repair to be performed during a scheduled idle time of the line.

Problems and Solutions

Problem: 1

A workshop has 20 nos. of identical machines. The failure pattern of the machine is given below:-

Elapsed time after Maintenance attention (in month)	Probability of failure
1	0.20
2	0.15
3	0.15
4	0.15
5	0.15
6	0.20

It costs Rs. 150 to attend a failed machine and rectify the same. Compute the yearly cost of servicing the broken down machines.

Solution:

Expected time before failure.

$= 0.20{\times}1{+}0.15{\times}2{+}0.15{\times}3{+}0.15{\times}4{+}0.15{\times}5{+}0.15{\times}6 = 3.5$ months

Therefore number or repair/machine/annum = 12/3.5

Considering 20 machines and Rs. 150 to attend a failed machine the yearly cost of servicing

$= 12/3.5{\times}20{\times}150 =$ Rs.10286.

Problem: 2

A Public transport system is experiencing the following number of breakdowns for months over the past 2 years in their new fleet of vehicles:

Number of breakdowns	0	1	2	3	4
Number of months this occurred	2	8	10	3	1

Each break down costs the firm an average of Rs. 2,800. For a cost of Rs. 1,500 per month, preventive maintenance can be carried out to limit the breakdowns to an average of one per month. Which policy is suitable for the firm?

Solution:

Converting the frequencies to a probability distribution and determining the expected cost/month of breakdowns we get:

No. of breakdowns	Frequency in months	Frequency in per cent	Expected Value
0	2	0.083	0.000
1	8	0.333	0.333
2	10	0.417	0.834
3	3	0.125	0.375
4	1	0.042	0.168
			Total 1.710

Breakdown cost per month; Expected cost = 1.710×Rs.2800 = Rs.4788.

Preventive maintenance cost per month: -

Average cost of one breakdown/month = Rs.2, 800

Maintenance contract cost/month = Rs. 1,500

Total = Rs. 4,300.

Thus, preventive maintenance policy is suitable for the firm.

Problem: 3

Indian Electronics, manufactures TV sets and carries out the picture tube testing for 2000 hours. A sample of 100 tubes was put through this quality test during which two tubes failed. If the average usage of TV by the customer is 4 hours/day and if 10,000 TV sets were sold, then in one year how many tubes were expected to fail and what is the mean time between failures for these tubes?

Solution:

The total test time = (100 tubes) × 2000 hours = 200,000 tube-hours.

There are two tubes which have failed and hence the total time is to be adjusted for the number of hours lost due to the failures during the testing.

The lost hours are computed as = $2 \times \frac{2000}{2}$ = 2000 hours.

The assumption is made here is that each of the failed tubes have lasted an average of half of the test period.

Therefore, the test shows that there are two failures during (2,00,000 – 2000) = 1,98,000 tube hours of testing.

During 365 days a year (four hours a day) for 10,000 tubes the number of expected failures

$$\frac{2}{1{,}98{,}000} \times 10{,}000 \times 365 \times 4 = 147.47 = 148 \text{ tubes approximately.}$$

$$\text{Mean time between failures} = \frac{1{,}98{,}000 \text{ tubes hrs. of testing}}{2 \text{ failures}}$$

$$= 99{,}000 \text{ tubes hours per failure} = \frac{99{,}000}{4 \times 365} = 67.8 \text{ tubes year per failure}$$

Problem: 4

A company has 50 identical machines in its facilities. The cost of preventive servicing (C_p) is Rs. 20, and the cost of repair after breakdown (CR) is Rs. 100. The company seeks the minimum cost preventive servicing frequency and has collected the data on breakdown probabilities in the following table:

Probabilities of machine breakdown, by month:

Months after servicing that breakdown occurs (i)	Probability that breakdown will occur (Pi)	$i.P_i$
1	0.10	0.10
2	0.05	0.10
3	0.05	0.15
4	0.10	0.40
5	0.15	0.75
6	0.15	0.90
7	0.20	1.40
8	0.20	1.60
	1.00	5.40

Solution:

The mean time before failure is 5.4 months and the expected cost with no preventive maintenance would be 100 x $\frac{50}{5.4}$ = Rs. 925.93 per month. The following calculations show B_j, the expected number of breakdowns between preventive maintenance intervals, for the possible intervals, that may be considered.

$B_1 = MP_1 = 50\ (0.10) = 5$

$B_2 = m\ (P_1 + P_2) + B_1P_1 = 50(0.10+0.05) + 5(0.10) = 8$

$B_3 = 50\ (0.10 + 0.05 + 0.05) + 8\ (0.10) + 5\ (0.05) = 11.05$

Accordingly, $B_4 = 16.75$, $B_5 = 25.63$, $B_6 = 35.5$, $B_7 = 48.72$, $B_8 = 63.46$.

The costs of various preventive maintenance intervals are summarised in the table below :
Cost of alternative preventive maintenance intervals –

Number of months between preventive services (j)	Bj Expected Number of Breakdown in j months	Expected cost/month to Repair Breakdown $C_R \times Bj/j$	Cost per month for preventive service every j month $C_R(M)/j$	Total expected cost per month of preventive maintenance and repair
(1)	(2)	(3)	(4)	(5)
1	5.00	500.00	1000.00	1500.00
2	8.00	400.00	500.00	900.00
3	11.05	368.33	333.33	701.66
4	16.75	418.75	250.00	668.75
5	25.63	512.60	200.00	712.60
6	35.50	591.67	166.67	758.34
7	48.72	696.00	142.86	838.86
8	63.46	793.25	125.00	918.25

A policy of performing preventive maintenance every 4 months results in the lowest average cost, about Rs. 669. This amount is Rs. 257 per month less than the Rs. 926 expected cost without preventive maintenance. This policy would reduce the costs by (257 ÷ 926) × 100 = 27.75% below the cost of repairing the machines only when they breakdown.

STUDY NOTE - 4

Resource Management

4.0 Input-output Ratio

Input-output analysis reflects a general theory of production based on the idea of economic interdependence. Many input - output models are useful in forecasting. Input - output analysis takes into consideration the interdependence of the different sectors in the economy. This is because; the input to one sector is output of another sector. For example, the output of coal industry will be an input to the steel plant and the output of steel industry is an input to the construction industry and so on. There are many such cyclic relations within the various sectors of economy. Taking the data of outputs and inputs and studying the relationship between these two, we will be in a position to analyse the total demand for a product and the output required from industrial units. This type of analysis is very important because it takes into account all the intricate relationships in the economy. One of the limitations in this method is that the utility of an output is restricted to economic analysis, not considering the other business, governmental, technological and internal factors. It is limited but useful analysis. The analysis need not be limited to macro-level, speaking only in terms steel sector and coal sector etc. It may be mote 'micro', by considering the inputs and outputs within a general product group in the total economy. This type of analysis is very much used and is found more beneficial and useful. Three major assumptions in developing this technique are:

1. The total output of an industry is consumed as input by all industries for a time period, under consideration.
2. The input bought by each industry has usually been made dependent only on the industry's level of output.
3. The ration of an industry's input to its output, once established is fixed. This ratio is known as input-output number or production coefficient.

Input-output analysis is a mathematical study of an economy in which different production sectors such as agriculture, industry and services etc. have interdependence. Thus, in input-output analysis, we try to analyse quantitatively the interdependence of inputs and outputs of various industries and find the equilibrium between the inputs and output of each industry, plant, sector or economy. The output of any industry depends very much on its inputs and these inputs are the outputs of other industries. This analysis signifies to foretell the total production per sector and its demand in other industries.

It can be presented as: Total output of all sectors = Total inputs of all sectors.

or, output of an industry = Total inputs of that industry.

This input-output analysis is also known as 'analysis of inter-industry or inter-sector flows or deliveries or analysis of inter-industry relations.'

Input-output analysis can be used in the following cases:

1. The input-output analysis can be used for the study of variation in productivity of an enterprise. This analysis is based on index-numbers, using value added measure for output and the measures of inputs all at constant prices. The value added in each industry can be obtained by subtracting the value of inputs used from the value of gross output.
2. Input-output table has a historic importance showing a record of past and can be a very useful instrument in economic analysis and framing economic policy. In developed countries, this analysis

is used for economic forecasting and in developing countries, for economic planning or programming. In business world, business forecasting can be done by this analysis.

3. This analysis can be very usefully used for a comparative study of growth by examining. By examining country-wise or sector or region-wise or plant, firm or industry-wise differences in input-output coefficients, the process of growth can be more easily interpreted.

4. This analysis can be utilised to determine the impact of some major exogamous changes in the economy on other factors of production.

4.1 Linear Programming

The solution technique for linear optimisation models is linear programming.

Linear programming is very important tool of operation research which has recently been started in the field of production management. It is new mathematical technique developed while the World War II was in progress. Before the inception of this technique in production management, every problem was tackled by trial and error method, the result of which was not so sure and best to the satisfaction. By introducing the technique, the solution of every problem now does not depend on chance; it is now tackled with some certainty by the use of this method.

Every business has limited resources (men materials, labour, money etc.) but wants to achieve its main objective of getting the maximum profit. Maximisation of profit of the business depends upon a number of variables so there may be a number of alternatives before the managing executives to maximise the profits. The business executives are, therefore, busy in choosing the most appropriate (best possible) action among a number of alternative courses of action. As there are a large numbers of variables to be considered for each alternative, the situation becomes more complicated. The management is to choose the best possible combination of variables. Even if information about variables is available, the problem is not so easy when we go in detail. It is infrequently so intricate the detail and in the interrelationships involved as to make it possible to use in its complexity. Previously these combinations were determined by trial and error method and no one could ascertain whether a best solution had been obtained or not. The linear programming has made it very simple to know about the best possible solution of any problem. Linear programming is applied to problems which involves interaction between alternatives.

Linear programming is a recently-developed technique which is being used in production management. It is technique of choosing a best possible alternative among the various alternatives available difficult because each alternative consists of a large number of variables, giving different results. Linear programming technique has considerably simplified the problem.

Linear programming consists of two words—'linear' and 'programming'. The word 'linear' establishes certain relationships among different variables whereas the word 'programming' indicates a way to get desired results by the optimum use of available resources. Thus linear programming is a mathematical technique for allotting limited resources in an optimum manner. Hence, it is of great practical significance for the management for achieving the prime objective of the business, i.e., maximisation of profits. It is an undisputable fact that resources of a business are limited setting limit or restriction on the smooth functioning of the business. The problem confronting the management is to decide the manner in which these limited resources are to be earmarked for various' uses so as to have the maximum profit. Linear programming technique solves this problem.

Linear programming is a planning technique that permits some objective functions to be minimised or maximised within the framework of given situational restrictions.

It is a planning technique by using the mathematical equations. It can be said as a technique of selecting the best possible (optimal) strategy among a number of alternatives. The chosen strategy is said to be the best because it involves maximisation or minimisation of some desired action, e.g., maximisation of profits or minimisation of costs.

Uses or Application of Linear Programming:

The linear programming technique is useful in the following cases:

(i) It helps in determining optimum combination of several variables with given constraints and thus selecting the best possible strategy among various alternatives available.

(ii) Linear programming provides additional information for proper planning and control over various operations in the organisation.

(iii) The management must understand the activities of the organisation for constructing suitable mathematical model visualising the relationship between variables, if any, and making improvement over them. The linear programming helps in better understanding the phenomenon.

(iv) Linear programming contributes to the development of executives through the techniques of model building and their interpretations.

(v) Linear programming provides standards for the management problems by defining (a) the objectives to be pursued, (b) various restrictions to be imposed, (c) various alternatives available and relationship between them, (d) the contribution of each alternative to the objectives.

Application: The linear programming technique may be fruitfully applied in the following spheres:

(i) The linear programming can be used in production scheduling and inventory control so as to produce the maximum out of the resources available to satisfy the needs of the public by minimising the cost of production and the cost of inventory control.

(ii) The technique of linear programming can also be fruitfully used in solving the blending problems. Where basic components are combined to produce a product that has certain set of specifications and one may calculate the best possible combination of these compounds which maximise the profits or minimise the costs.

(iii) Other important applications of linear programming can be in purchasing, routing, assignment and other problems having selection problems such as(a) selecting the location of plant, (b) deciding the transportation route within the organisation, (c) utilising the godowns and other distribution centres to the maximising, (d) preparing low-cost production schedules, (e) determining the most profitable product-mix , and (f) analysing the effects of changes in purchase prices and sale prices.

L*imitations of Linear Programming:* Linear programming, as the name suggests, presents the relations between different variables in a line. This presumption, however, is not correct. There are many limitations of linear programming which can be given below:

(i) The technique solves the problems of linear nature whereas, in practice, most of the business problems are of non-linear nature. The solution of non-linear problems is not possible through this technique.

(ii) This technique cannot provide solutions to problems which involve variables not capable of being expressed quantitatively.

(iii) Under this technique, uncertainties are not considered whereas in business, every problem is full of uncertainties.

(iv) One of the limitations of linear programming is that the results under this technique are not necessarily to be in whole numbers. Sometimes results in points give a misleading picture. For example, if it results by this technique that 1.6 machines are to be purchased, it becomes very difficult to ascertain whether to purchase one machine or two machines because machines cannot be purchased in fraction.

Formulation of an L.P problem: In formulating the linear programming problem, the basic step is to set up some mathematical model. For this purpose, the following considerations should be kept in mind: (i) unknown variables, (ii) objectives and (iii) constraints. This can be done with the help of the following terms:

1. **The objective function:** An objective function is some sort of mathematical relationship between variables under consideration. Under linear programming this relationship is always linear. The construction of objective function mainly depends upon abstraction. It is a process whereby the most important features of a system are considered.

   The objective function is always positive. The coefficients a_1, a_2 are certain constants and are known as prices associated to the variables X_1, X_2.

2. **Constraints on the variables of the objective function:** In practice, the objective function is to bee optimised under certain restraints imposed on die variables or some combination of few or all the variables occurring in the objective function. These restrictions, in most of the cases, are never exact. Had these been exact, the objective function would have been easily optimised by die use of differential calculus. The restraints should be known and expressed in terms of linear algebraic expression.

3. **Feasible solution:** One of the essential features of linear programming problem is optimisation of linear objective function Z. It is subject to the linear constraints on the variables of the objective function. A set of values of X_1, X_2.........which satisfies the constraints and the non- negativity restrictions are called Feasible solution. A feasible solution which optimises the objective function is known as Optimalsolution. Thus, a linear programming problem can be formulated in this way.

Simplex Method of Linear Programming

There are number of ways of finding the optimal solution for a given linear programming problems. The following three methods are mainly used for this purpose.

(1) Graphic Method

(2) Simplex Method

(3) Transportation Method.

1. **Graphic method.** This method is generally used for solving the problems having two or three variables. Due to this limitation of handling only two or three variables at a time this method has limited application in industrial problems. In practice, two variable cases are easy to solve by this method because three dimensional geometry becomes too complicated to find accurate results.

2. **Simplex Method.** This is the most powerful and popular method for solving linear programming problems. Any problem can be solved by this method which satisfies the conditions of linearity and certainty irrespective of the number of variables. It is an iterative procedure which ultimately gives the optimal solution.

3. **Transportation Method.** This method is used to know the minimum cost of transportation of a product from various origins to different distribution and consumption centres.

Simplex method of linear programming. Simplex method of linear programming is a very important technique to solve the various linear problems. Under this method, algebraic procedure is used to solve any problem which satisfies the test of linearity and certainty. It is an iterative procedure which ultimately gives the optimal solution. Several variables can be used under this method. However, the simplex method is more complex and involves somewhat unsophisticated complex mathematics.

Features. There are two characteristic features of the simplex method which we can cite them at the very outset.

First, we have the computational routine in the iterative process. Iteration means the repetition. Therefore, in working towards the optimal solution, the computational routine if repeated again and again, following a standard pattern, successive solutions are developed in a systematic pattern until the best solution is arrived.

Secondly, such new solution will give a profit larger than the previous solution. This important characteristic assures us that we are always moving closer to the optimal solution.

There are two types of linear programming problems to be solved by this method—

(1) Maximisation of objective function, and (2) Minimisation of objective function.

1. Maximisation of objective function. The following procedural steps are taken for getting the optimum solution by simplex method, which maximise the objective function. We shall explain the procedure of maximisation of objective function by simplex method with the help of the following illustration.

Illustration. A small manufacturing firm produces two types of gadgets, A and B, which are first processed in the foundry, then sent to the machine for finishing. The number of man-hours of labour required in each shop for the production of each unit of A and B and the number of man-hours the firm has available per week are as follows:

	Foundry	Machine shop
Gadget A	10	5
Gadget B	6	4
Firm's capacity per week (in hours)	1000	600

Construct the objective function and the corresponding constraints for calculating that how many units should be produced per week so that the profit is maximum. The profit on the sale of A is Rs. 30 per unit as compared to B's Rs. 20 per unit.

Taking this illustration, we can explain the following steps:

1. The first step is to know the objective function and the linear constraints for the given problem.

2. Slack variables. The next step is to change the inequalities for two constraints into equations. The inequalities are converted into equations only by the device of introducing slack variables. A slack

variable represents costless process whose function is to 'use up' otherwise unused capacity, say machine time or warehouse capacity. Effectually, the slack variable represents unused capacity, and it will be zero, only if production facilities or capacities are fully utilised. In each constrained equation, the variables used in other equations are also introduced but with zero coefficients. The same slack variables are also introduced in the objectives function but by the time it is maximum, all their coefficient will be zero. The equation can be developed as follows:

$Z = 30X + 20Y + 0S_1 + 0S_{2;}$

Subject to:

$10X + 6Y + 1S_1 + 0S_2 = 1000$

$5X + 4Y + 0S_1 + 1S_2 = 600$

Here, S_1 and S_2 are slack variables (unused time on machine 1 and 2 respectively). Slack variables are always non-negative.

3. Developing initial simplex tableau.We can now set out this whole problem in a simplex tableau and read it for a basic feasible solution. This table consists of rows and columns of figures and is also known a simplex matrix. Each table has the following columnwise heading from left to right:

(i)	(ii)	(iii)	(iv)	(v)	(vi)
Unit profit (C_j)	Basis or programme	Quantity or Constant	Slack Variables	Real Variables	Ratio

The following entries are made in each column as:

(i) The first column (unit-profit column) has zero entry in each row in the initial stage.

(ii) The second column (basis or programme column) shows the first feasible solution and contains various slack or artificial variables from top to bottom. The first feasible solution consists of those slack or artificial variables for which the corresponding column is an identity vector.

(iii) The third column (the quantity or constant column) will have the constant right hand side value of each constrained equation in the respective row.

(iv) The fourth column (slack variables column shall have the respective coefficients of the given slack variables in different constrained equations for each row. These coefficients will be either 1 or 0 depending whether the slack variables of the column appears in the corresponding constraint equation or not.

(v) The fifth column (real variables column) shall have the respective coefficients of the given real variables in different constraint equations for each row.

(vi) The six and last column (ratio column).

Now with the help of the given illustration, we can prepare the initial simplex tableau, illustrating the above steps:

Initial Simplex Tableau

		Top j	1	2	3	4	5	6
		C_j	0	0	0	30	20	
Row No.(l)	Unit Profit	Programme	Constant	Slack Variables		Real Variables		Ratio
				S_1	S_2	X	Y	
1	0	S_1	1000	1	0	10	6	
2	0	S_2	600	0	1	5	4	

It can be observed from the above table that the entries corresponding to the columns for slack variables S_1, and S_2 are (1,0) and (0,1) respectively. These are unit vector. Hence the programme column of the above table contains the slack variables S_1 and S_2 as its first feasible solution.

Thus Row 1 corresponds to constraint equation $10X + 6Y + S_1 + 0.S_2 = 1000$

and Row 2 corresponds to the constraint equation $5X + 4Y + 0S_1 + 1S_2 = 600$

4. Computation of base row. Having prepared the initial simplex tableau, the next step in the preparation of base row values from the initial tableau by the following procedure to get tableau I:
   (i) Multiply each row entry by the corresponding entry of unit profit column.
   (ii) Find the sum of the products obtained in step for each column and denote it by Z_j's.
   (iii) Subtract the corresponding objective factor C_j of top row from Z_j. The base row values can be positive, zero or negative.

The Z_j's and the base row values for the above illustration from the initial simplex tableau are calculated as below:

$Z_1 = (1000\times0) + (600\times0) = 0$ and $(Z_1 - C_1) = 0-0 = 0$

$Z_2 = (1\times0) + (0\times0) = 0$ and $(Z_2 - C_2) = 0 - 0 = 0$

$Z_3 = (0 \times 0) + (1\times 0) = 0$ and $(Z_3 - C_3) = 0 - 0 = 0$

$Z_4 = (10 \times0) + (5 \times 0) = 0$ and $(Z_4 - C_4) = 0 - 30 = -30$

$Z_5 = (6 \times 0) + (4 \times 0) = 0$ and $(Z_5 - C_5) = 0 - 20 = -20$

The simplex tableau now will be

Tableau I

		j	1	2	3	4	5	6
		C_j	0	0	0	30	20	
	Unit profit	Progr-amme	Constant	S_1	S_2	X	Y	Ratio
→	0	S_1	1000	1	0	10	6	100
Key Row	0	S_2	600	0	1	5	4	120
Base	→	Z_j	0	0	0	0	0	
Row Values		Z_j-C_j	0	0	0	-30	-20	
						Key Column		
					Negative largest values			

5. Examining base row values. Examine all base row values in Tableau I. If they (all values) are positive, it is the optimum solution and the solution can be read from constant and programme columns. If all values (Z_j-C_j) are negative, the largest numerically negative value among the base row values should be searched. The column in which the largest value lies is known as key column. In the above case, column 4 is the key column. And now we should proceed to step (6) and (7) below.

6. Computation of ratio column. Having located the key column, the next step is to compute the ratio column. This may be done by dividing the constant column value of each row by key column entry of that row. So, in Tableau I, the ratio column comes to 1000/10 and 600/5.

   Now examine the ratio-column of tableau to locate the key row.

   The row for which entry in ratio column is non-negative and numerically smallest is taken as the key row. For example, in Tableau I the least non-negative entry in the ratio column is 100 hence Row I is the key row. Negative values in the ratio column are not considered because solution values of real variables cannot be negative.

   The entry lying in the cell at the intersection of key row and key column is known as key number, e.g., in Tableau I, 10 is the key number.

7. Preparation of Tableau II and Tableau III. After identifying key row, key column and key number in Tableau I in step (6), Tableau II is prepared having some columns but with the following changes :

   (i) In Tableau II, the slack variables lying in the programme column of key row of tableau I is replaced by variable of the key column in tableau I, e.g., in tableau II of the above example, the entry in programme column of key row is obtained by replacing the slack variable S_1 in the programme column of the key row in tableau I by the variable Y.

   (ii) The value of C_j lying in the key column of Tableau I is entered in profit column of key row in tableau II, e.g., 30 is written in profit column of Row I.

   (iii) The remaining entries of the row in tableau II corresponding to key row in tableau I are obtained by dividing the corresponding entries of key row in tableau I by key number, e.g., the entry in first row and constant column of tableau II shall be 100 (100/10). Similarly, other entries in Row; I are (1/10, 0/10, 10/10 and 6/10). Now the tableau II will be as under:

Tableau II

		j	1	2	3	4	5	6
		C_j	0	0	0	30	20	
	Unit profit	Progr-amme	Constant	S_1	S_2	X	Y	Ratio
1	30	X	100	0.5	0	1	0.6	167
							key number	
2	0	S_2	100	-0.5	1	0	1	100
Key row →								
		Z_j	3000	3	0	30	18	
		Z_j-C_j	3000	3	0	0	-2	
						Key column		

(iv) The entries in Row 2 of tableau II are made in the following way : The entry for any column in Row II of Tableau II is obtained by multiplying the entry in the row of Tableau II obtained in step (iii) above by the value lying in key column of row in tableau I and then subtracting the product from the corresponding entry of the column in Row II of Tableau I, e.g., 100 in constant column of Row II in tableau II is equal to 600 - (100 × 5) = 100.

Similarly other entries in Row II in Tableau II are

[(0 - (0.1 × 5) = - (0.5)], [(1- (0 × 5) - 1)], [(5 - (1 × 5) =0)], [(4 - (0.6 ×5) =1)].

The base row in Tableau II is obtained by applying the operations in step (4) on the values of Tableau II and it is examined whether the optimal solution is obtained or not. If optimal solution is reached, we shall stop at this point. If not, operations in step (6) and (7) will be repeated on the entries in Tableau II to get the tableau III and so on the procedure is repeated till we get the optimal solution.

It is observed from Tableau II of the given problem that only Z_j-C_j is negative. Hence the column No. 5 of tableau II is the, key column. Similarly from the ratio column of Tableau II we find the entry 100 in row II is minimum hence Row II become the key row and I is the key number.

The Tableau III will now be prepared as

Tableau III

Unit profit	C_j Programme	0 Constant	0 S_1	0 S_2	30 X	20 Y
30	X	40	0.4	-0.6	1	0
20	Y	100	-0.5	1	0	0
	Z_j	3,200	2	2	30	20
	Z_j-C_j	3,200	42	2	0	0

In Tableau III all Z_j-C_j are non-negative. Hence the optimal solution is reached. From programme and constant columns of Tableau III, the result is read as X = 40, Y = 100 with minimum profit of Rs. 3,200.

2. Minimisation of objective function. The second problem of simplex method is minimisation of objective function. For this purpose, the problem is first changed to maximisation problems by writing Z* = -Z = -(aX + bY)

Thus, the constraint remains unchanged. The maximum value of Z* is determined on the same lines as described in maximisation problem. Maximisation of Z* implies minimisation of Z.

Degeneracy Method. Sometimes, it happens that during the course of simplex procedure, we get two or more entries in the ratio column of any tableau to be identical and minimum. Now, the question arises which row should be taken as key row? The selection of key row determines the variable to be deleted. This is known as degeneracy. The problem of degeneracy may also occur when one of the constraints on the right hand side of the equation is zero.

The degeneracy is resolved by the following procedure:

(a) Each element of the row which have identical entries in the ratio column is divided by the key column number of the respective row.

(b) The values so obtained are compared step by step from left to right. Priority is to be given to identify columns corresponding to slack and artificial variables. The remaining columns are considered from left to right.

(c) The comparison is stopped as soon as the rows yield unequal ratios. The row having algebraically smaller ratio is taken to be the key row.

After selecting the key row, regular simplex procedure is resumed.

Slack and Artificial Variables

Slack variables.

A slack variable represents costless process whose function is to 'use up otherwise unemployed capacity, say, machine hour or warehouse capacity. Effectually the slack variable represents unused capacity and it will be zero only, if production facilities are fully utilisesd. There are always non-negative or positive and explains the unallocated portion the given limited resources. The main purpose of introducing slack variables in the simplex method of linear programming is to convert the inequalities(i.e., constraints); into equalities or, say, equations.

Artificial variables: The artificial variables are fictitious and do not have any physical meaning. These variables are assigned a very large per unit penalty in the objective function. The penalty is designated as –M for maximisation problem and +M in minimisation problem where M is always greater than zero.

There may be situations where the constraints involve mixture of $\geq$ = and $\leq$ signs. In such cases, the slack variables cannot provide a starting feasible solution and we have to introduce both slack and artificial variables to have a starting basis. The artificial variables are denoted as $A_1, A_2 \ldots\ldots\ldots A_n$ in the programme column of initial simplex tableau. These artificial variables should be removed first by using simplex criterion. If at any stage of simplex procedure the basic feasible solution contains artificial variable but the variable to be deleted at that stage is not the artificial variable, it means we are departing from the simplex criterion for selecting the variable.

The iterative procedure does not work under following circumstances -

(i) One or more artificial variables appeals in the program column at a stage when the base row values are all positive.

(ii) No artificial variables remain in the programme column.

(iii) The problem is redundant if one or more artificial variables occur in programme column and the corresponding values in the constant column are zero at a stage when all Zj-Cj are positive or non-negative.

Problems and Solutions

Problem 1. Find the non-negative values of $X_{1,}$ X_2 and X_3 that maximise the expression

$$Z=3X_1+5X_2+4X_2$$

subject to the following restraints

$$2X_1 + 3X_2 \leq 8$$

$$2X_2 + 5X_3 \leq 10$$

$$3X_1 + 2X_2 + 4X_3 \leq 15$$

Solution :

By introducing the slack variables to change the restrictions into equalities, we get;

$2X_1 + 3X_2 + S_1 = 8$

$2X_2 + 5X_3 + S_2 = 10$

$3X_1 + 2X_2 + 4X_3 + S_3 = 1$

Now, objective function becomes

$Z = 3X_1 + 5X_2 + 4X_3 + 0S_1 + 0S_2 + 0S_3$

Now various tables are prepared to get the non-negative values of X_1, X_2 and X_3 to maximise Z in the following way:

Tableau I

		C_j	3	5	4	0	0	0	
Profit	Programme	Constant	X_1	X_2	X_3	S_1	S_2	S_3	Ratio
0	S_1	8	2	3	0	1	0	0	2.67
0	S_2	10	0	2	5	0	1	0	5
0	S_3	15	3	2	4	0	0	1	7.5
Z_j		0	0	0	0	0	0	0	
C_j-Z_j		-	3	5	4	0	0	0	

Tableau II

		C_j	3	5	4	0	0	0	
Profit	Programme	Constant	X_1	X_2	X_3	S_1	S_2	S_3	Ratio
5	X_2	8/3	2/3	1	0	1/3	0	0	
0	S_2	14/3	- 4/3	0	5	-2/3	1	0	
0	S_3	20/3	5/3	0	4	-2/3	1	1	14/15
Z_j		40/3	10/3	5	0	5/3	0	0	29/12
C_j-Z_j		-	- 1/3	0	4	-5/3	0	0	

Tableau III

		C_j	3	5	4	0	0	0	
Profit	Programme	Constant	X_1	X_2	X_3	S_1	S_2	S_3	Ratio
5	X_2	8/3	2/3	1	0	1/3	0	0	4
4	X_3	14/15	-4/15	0	1	-2/15	1/5	0	-7/2
0	S_3	89/15	41/15	0	0	-2/15	-4/5	0	89/41
Z_j		34/15	5	4	17/15	4/5	0	0	
C_i-Z_j		-	11/15	0	0	-17/15	-4/5	0	

Tableau IV

		C_j	3	5	4	0	0	0	
Profit	Programme	Constant	X_1	X_2	X_3	S_1	S_2	S_3	Ratio
5	X_2	150/123	0	1	0	45/123	24/123	0	
4	X_3	930/615	0	0	1	-90/615	75/615	0	
3	X_1	89/41	1	0	0	-2/41	-12/14	0	
Z_j		765/41	3	5	4	45/41	24/41	0	
C_i-Z_j		-	0	0	0	-45/41	-24/41	0	

Thus, in Table IV all C_j-Z_j are zero or negative hence it is the optimal solution.

In this, X_1=89/41; X_2 =150/123 and X_3 =930 /615 or 62/41

and maximum profit Z = 765/41

Problem 2. Find the maximum value of $Z = 3X_1 + 5X_2 + 4X_3$. Where $X_1, X_2, X_3 \geq 0$ subject lo the following constraints.

$2X_1 + 3X_2 \leq 18$

$2X_2 + 5X_3 \leq 18$

$3X_1 + 2X_2 + 4X_3 \leq 25$

Solution:

As here the objective function is to be maximised, we shall introduce the slack variables in the constraints and the objective function and we get the following equations:

$2X_1 + 3X_2 + S_1 + 0.S_2 + 0.S_3 = 18$

$2X_2 + 5X_3 + 0.S_1 + S_2 + 0.S_3 = 18$

$3X_1 + 2X_2 + 4X_3 + 0.S_1 + 0.S_2 + S_3 = 25$

So, $Z = 3X_1 + 5X_2 + 4X_3 + 0S_1 + 0S_2 + 0S_2$

Now, various simplex tableaus are prepared to get the optimal solution.

Tableau I

		C_j	0	0	0	3	5	4	Ratio
Profit	Programme	Constant	S_1	S_2	S_3	X_1	X_2	X_3	
0	S_1	18	1	0	0	2	3	0	6
0	S_2	18	0	1	0	0	2	5	9
0	S_3	25	0	0	1	3	2	4	12.5
	Z_j	0	0	0	0	0	0	0	
	$Z_j - C_j$	—	0	0	0	–3	–5	–4	

Tableau II

		C_j	0	0	0	3	5	3	Ratio
Profit	Programme	Constant	S_1	S_2	S_3	X_1	X_2	X_3	
5	X_2	6	1/3	0	0	2/3	1	0	α
0	S_2	6	-2/3	1	0	4/3	0	5	6/5
0	S_3	13	-2/3	0	1	5/3	0	4	13/4
	Z_j	30	5/3	0	0	10/3	0	0	
	$Z_j - C_j$	-	5/3	0	0	1/3	0	-4	

Tableau III

		C_j	0	0	0	3	5	4	Ratio
Profit	Programme	Constant	S_1	S_2	S_3	X_1	X_2	X_3	
5	X_2	6	1/3	0	0	2/3	1	0	9
4	X_3	6/5	-2/15	1/5	0	-4/15	0	1	Neg.
0	S_3	41/5	-2/15	-4/5	1	41/15	0	0	3
	Z_j	74/5	17/15	4/5	0	34/15	5	4	
	$Z_j - C_j$	–	17/15	4/5	0	11/15	0	0	

Tableau IV

	Programme	C_j	0	0	0	3	5	4	
Profit		Constant	S_1	S_2	S_3	X_1	X_2	X_3	Ratio
5	X_2	4	15/41	8/41	-10/41	0	1	0	
4	X_3	2	-6/41	5/41	4/41	0	0	1	
3	X_4	3	-2/41	-12/41	15/41	1	0	0	
	Z_j	37	45/41	24/41	15/41	3	5	4	
	Z_j - C_j		45/41	24/41	15/41	0	0	0	

In Tableau IV all $Z_j - C_j$ are non-negative or positive hence it is the optimal solution. The optimal solution is $X_1 = 3$; $X_2 = 4$; $X_3 = 2$ and the maximum profit $Z_j = 37$.

Problem 3. Maximise $3X_1 + 2X_2$ under the following restrictions:

$X_1 > 0, X_2 \geq 0$

$2X_1+X_2 \leq 40$

$X_1+X_2 \leq 24$

$2X_1+3X_2 \leq 60$

Solution. By introducing slack variables in constraints, we get

$2X_1 + X_2 + S_1 +0S_2 + 0S_3 = 40$

$X_1 + X_2 + 0S_1+ S_2 + 0S_3 = 24$

$2X_1 + 3X_2 + 0S_1 + 0S_2 + S_3 = 60$

and the objective function (Z) now can be represented by

$Z = 3X_1 + 2X_2 + 0S_1+ 0S_2 +0S_3$

Now, the following tableaus are to be prepared to get the optimal solution:

Tableau I

		C_1	3	2	0	0	0	
Profit	Programme	Constant	X_1	X_2	S_1	S_2	S_3	Ratio
0	S_1	40	2	1	1	0	0	20
0	S_2	24	1	1	0	2	0	24
0	S_3	60	2	3	0	0	1	30
	Z_j	0	0	0	0	0	0	
	$C_j – Z_j$		3	2	0	0	0	

Tableau II

		C_1	3	2	0	0	0	
Profit	Programme	Constant	X_1	X_2	S_1	S_2	S_3	Ratio
3	X_1	20	1	1/2	1/2	0	0	40
0	S_2	4	0	1/2	–1/2	1	0	8
0	S_3	20	0	2	–1	0	1	10
	Z_j	60	3	3/2	3/2	0	0	
	$C_j – Z_j$	—	0	1/2	–3/2	0	0	

Tableau III

		C_1	3	2	0	0	0	
Profit	Programme	Constant	X_1	X_2	S_1	S_2	S_3	Ratio
3	X_1	16	1	0	1	–1	0	
2	X_2	8	0	1	–1	2	0	
0	S_3	4	0	0	1	–4	1	
	Z_j	64	3	2	1	1	0	
	$C_j – Z_j$	—	0	0	–1	–1	0	

Since all Cj-Zj are either zero or negative, it is the optimal solution of the problem. Here X_1,

= 16; X_2 = 8 and maximum profit Z_j = 64.

Problem 4. A company manufactures two items X_1 and X_2. They are sold at a profit of Rs. 30 per unit of X_1 and Rs. 20 per unit of X_2. X_1 requires 2kgs of materials, 3 man-hours and 1 machine hour per unit. X_2 requires 1 kg of material, 2 man hours and 3 machine hours per unit.

During each production run there are 280 kgs of material available, 500 labour hours and 420 hours of machines used. How much of the two items should the company produce to maximize profits?

Maximise $30X_1 + 20X_2$ subject to

$2x_1+x_2 \leq 280$

$3x_1 + 2x_2 \leq 500$

$x_1 + 3x_2 \leq 420$

$x_1, x_2, x_3 \geq 0$

Solution.

The objective function to be maximised in this problem may be expressed in the following way:

$Z = 30X_1 + 20X_2$

Subject to constraints

$2x_1 + x_2 \leq 280$

$3x_1 + 2x_2 \leq 500$

$x_1 + 3x_2 \leq 420$

$x_1, x_2, x_3 \geq 0$

Now, by introducing slack variables, we get

$2X_1 + X_2 + S_1 + 0S_2 + 0S_3 = 280$

$3X_1 + 2X_2 + 0S_1 + S_2 + 0S_2 = 500$

$X_1 + 3X_2 + 0S_1 + 0S_2 + S_3 = 420$

and $Z = 30X_1 + 20X_2 + 0S_1 + 0S_2 + S_3$

Now, various tables will be prepared as under:

Tableau I

		C_j	30	20	0	0	0	
Profit	Programme	Constant	X_1	X_2	S_1	S_2	S_3	Ratio
0	S_1	280	2	1	1	0	0	140
0	S_2	500	3	2	0	1	0	166.67
0	S_3	420	1	3	0	0	1	420
	Z_j	0	0	0	0	0	0	
	C_j-Z_j		30	20	0	0	0	

Tableau II

		C_j	30	20	0	0	0	
Profit	Programme	Constant	X_1	X_2	S_1	S_2	S_3	Ratio
30	X_1	140	1	1/2	1/2	0	0	280
0	S_2	80	0	1/2	-3/2	1	0	160
0	S_3	280	0	5/2	-1/2	0	1	112
	Z_j	4200	30	15	15	0	0	
	C_j-Z_j	0	0	5	-15	0	0	

Tableau III

		C_j	30	20	0	0	0	
Profit	Programme	Constant	X_1	X_2	S_1	S_2	S_3	Ratio
30	X_1	84	1	0	3/5	0	-1/5	
0	S_2	24	0	0	-7/5	1	-1/5	
20	X_2	112	0	1	-1/5	0	2/5	
	Z_j	4760	30	20	14	0	25/2	
	C_j-Z_j	—	0	0	-14	0	-25/2	

In the above Tableau III, all C_j-Z_j are zero or negative, hence it is optimal solution $X_1 = 84$; $S_2 = 112$ and maximum profit $(Z_j) = 4,760$.

Problem 5. An animal feed company must produce 200 lbs. of a mixture containing the ingredients X_1 and X_2. X_1 costs Rs. 3 per Ib. and X_2 costs Rs. 8 per Ib. Not more than 80 lbs of X_1 can be used and minimum quantity to be used for X_2 is 60 lbs. Find how much of each ingredient should be used if the company wants to minimise the cost.

Solution:

In the above problem, the objective function to be minimised is—

$Z = 3X_1 + 8X_2$, subject to the following constraints—

$X_1 \leq 80$; $X_1 + X_2 = 200$; $X_2 \geq 60$.

As, in this problem, the constraints contain all the symbols, $\leq$, = , $\geq$, so slack and artificial variables to change the restrictions into equalities and we get—

$X_1 + S_1 = 80$;

$X_1 + X_2 + A_1 = 200$ and

$X_2 - S_2 + A_2 = 60$

Hence the objective function becomes—

$Z^* = -Z = -3X_1 - 8X_2 + 0S_1 + 0S_2 - M.A_1 - M.A_2$

Here Z * is to be minimised, hence penalty for A_1 and A_2 in the objective function will be -M. The various tableaus under simplex method will be prepared in the following manner -

Tableau I

		C_j	0	0	-M	-M	-3	-8	
Profit	Programme	Constant	S_1	S_2	A_1	A_2	X_1	X_2	Ratio
0	S_1	80	1	0	0	0	1	0	
-M	A_1	200	0	0	1	0	1	1	200
-M	A_2	60	0	-1	0	1	0	1	60
Z_j			0	M	-M	-M	-M	-2M	
$Z_j - C_j$			0	M	0	0	3-M	8-2M	

Tableau II

		C_j	0	0	-M	-M	-3	-8	
Profit	Programme	Constant	S_1	S_2	A_1	A_2	X_1	X_2	Ratio
0	S_1	80	1	0	0	0	1	0	80
-M	A_1	140	0	0	1	-1	1	0	100
0	X_2	60	0	1	0	-1	0	1	
Z_j			0	-M+8	-M	M-8	-M	-8	
$Z_j - C_j$			0	-M+8	0	2M-8	-M+8	0	

Tableau III

		Cj	0	0	-M	-M	-3	-8	
Profit	Programme	Constant	S_1	S_2	A_1	A_2	X_1	X_2	Ratio
-3	X_1	80	1	0	0	0	1	0	
-M	A_1	60	-1	1	1	-1	0	0	60
-8	X_2	60	0	-1	0	1	0	1	-60
Z_j		-1200	5	0	0	0	-3	-8	
$Z_j - C_j$			5	0	M	M	0	0	

Here all Z_j-C_j in Tableau IV are positive, hence it is the optimal solution. This is given X_1= 80, X_2 = 120, the minimum value being Rs. 1200.

Problem: 6

The annual hand made furniture show and sales occurs next month and the school of vocational studies is playing to make furniture for the sale. There are three wood working classes - I year, II year, III year at the school and they have decided to make three styles of chairs A, B and C. Each chair must receive work in each class and the time in hours for each chair in each class is given.

Chair	I year	II year	III year
A	2	4	3
B	3	3	2
C	2	1	4

In the next month there will be 120 available in I year class, 160 in the second year class and 100 hours in third year class to produce chairs. The teacher of the wood working class feels that a maximum of 40 chairs can be sold at the show. The teacher has determined that the profit from each type of chair will be A — Rs. 40, B — Rs. 35 and C — Rs. 30.

Formulate a linear programming model to determine how many chairs should be produced to maximise profit.

Solution:

Let x_1, are the chairs produced of A type

x_2 are the chairs produced of B type

x_3 are the chairs produced of C type

Formulation

$2x_1 + 3x_2 + 2x_3 \leq 120$

$4x_1 + 3x_2 + x_3 \leq 160$

$3x_1 + 2x_2 + 4x_3 \leq 100$

$x_1, x_2, x_3 \geq 0$

Objective function

Maximise $Z = 40x_1 + 35x_2 + 30x_3$

The problem is solved by simple method, convert inequalities into equalities by adding slack variables

S.T.

$2x_1 + 3x_2 + 2x_3 + x_a = 120$

$4x_1 + 3x_2 + x_3 + x_b = 160$

$3x_1 + 2x_2 + 4x_3 + x_c = 100$

Rewriting objective function as $Z - 40x_1 - 35x_2 - 30x_3 = 0$

Selection of non-basic variables n – m = 6 - 3 = 3

where n = No. of variables

m = No. of constraint equation, where x_a, x_b and x_c are slack variables.

Non basic variables $x_1 = x_2 = x_3 = 0$ gives.

$\therefore\ x_a = 120$

$\therefore\ x_b = 160$

$\therefore\ x_c = 100$

The initial solution is represented in starting table.

Starting table

Basics	Z	x_1	x_2	x_3	x_a	x_b	x_c	RHS	Ratio
Z	1	-40	-35	-30	0	0	0	0	-
x_a	0	2	3	2	1	0	0	120	60
x_b	0	4	3	1	0	1	0	160	40
x_c	0	3	2	4	0	0	1	100	33.33

Entering variable x_1 leaving variable = x_c literation no. 1

Basics	Z	x_1	x_2	x_3	x_a	x_b	x_c	RHS	Ratio
Z	1	0	- 25/3	70/3	0	0	40/3	4000/3	-
x_a	0	0	5/3	- 2/3	1	0	- 2/3	160/3	32
x_b	0	0	1/3	- 13/3	0	1	- 4/3	80/3	80
x_c	0	1	2/3	4/3	0	0	1/3	100/3	50

Entering variable x_2 leaving variable = x_a literation no.2

$\therefore$

Basics	Z	x_1	x_2	x_3	x_a	x_b	x_c	RHS	Ratio
Z	1	0	0	20	5	0	10	1600	-
x_a	0	0	1	- 2/5	3/5	0	- 2/5	32	
x_b	0	0	0	42/10	- 3/25	1	- 94/75	20	
x_c	0	1	0	19/9	- 2/5	0	17/15	12	

As Z row has all positive values hence optimal solution has reached

$\therefore\ Z = 1600$

$x_1 = 12$ units

$x_2 = 32$ units

$x_3 = 0$

Problem 7.

A company has three plants F_1, F_2 F_3 from which it supplies to 4 markets: ABCE. Determine the optimal transportation plan from the following table giving the plant to market shipping costs, quantities available

Plant ↓	Markets				
	A	B	C	D	Available at plant
F_1	13	11	15	20	2
F_2	17	14	12	13	6
F_3	18	18	15	12	7
Requirement	3	3	4	5	15

at each plant and quantities required at each market.

Solution:

The problem is balanced transportation problem because the demand and supply both are equal to 15. Now obtain the initial feasible solution by Vogel's method. The cost matrix and the penalties for

Factory	Warehouses Markets				Avail-Ability	Row Penalty
	A	B	C	D		
	(1)	(2)	(3)	(4)		
F1	13	11	16	20	2	(13 –11) = 2
F2	17	14	12	13	6	(13 – 12) = 1
F3	18	18	15	12	7	(15 – 12) = 3
Amount required	3	3	4	5	15	
Column penalty	(17–13) = 4	(14–11) =3	(15 - 12) =3	(13 – 12) =1	—	—

given problem are as under:

Now, penalty of first column is maximum and the lowest cost in column (1,1), i.e., Rs. 13, so allocate 2 units (maximum quantities available in F,) to cell (1,1) and delete row (1) as its requirements is complete.

Now penalty of column (2) is maximum and the lowest cost is 14 so, we can allocate 3 units to cell (2,2) as 3 units are the maximum requirement for market B. The requirement of column (2) is exhausted hence column (2) is deleted. The shrunken matrix becomes as—

Factory	Warehouse			Availability	Penalty
	(1)	(3)	(4)		
F_2	17	12	13	3	1
F_3	18	15	12	7	3
Requirement	1	4	5	10	
Penalty	1	3	1		

Now, we consider earlier row(3)or column(3)because both have minimum cost of Rs. 12. Let us consider column (3) and allocate 3 units to cell (2,3) and delete row $F_{2.}$ Now the balance will be allocated to row F_3. Thus, the initial solution by Vogel's method is given in the following table:

Factory	Warehouse				Availability
	A	B	C	D	
F_1	2	–	–	–	2
F_2	–	3	3	–	6
F_3	1	–	1	5	15
Requirement	3	3	4	5	7

Here m+n-1 =6 equal to the occupied cells hence solution is feasible. Now, the optimality can be tested by calculating the implicit cost for each cell. The calculations are given below:

Factory	Warehouse													Availability
	A				B			C			D			
F1	13			11			15			20				
			13			11			9			7	2	–5
F2	17			14			12			13				
					2			4					6	–2
			16			14			12			10		
F3	18			18			15			12				
		2			29						5		6	
			12			15			14			12		
Requirement		3			3			4			5		15	
V_j		18			16			14			12			

In the above table in cell 1,2, the implicit cost is greater than the actual cost hence 8 units' are allocated to (we get the following solution):

Factory	Warehouse				Availability
	A	B	C	D	
F1	2– θ	θ	–	–	2
F2	–	3– θ	3+ θ	–	6
F3	1– θ	–	1– θ	5	7
Required	3	3	4	5	15

In the above table, the minimum of negative θ is one hence take θ =1 and get the revised solution and test the optimality again with the help of the following table:

Factory	Warehouse													Availability
	A			B			C			D				
F1	13			11			15			20				
		2											–5	2
			13			12			10			17		
F2	17			14			13							
					3								–3	6
			15			14			9					
F3	16			18			15			12				
											5		0	7
			18			17			15			12		
V_j		18			17			15			12			
Required		3			3			4			5			15

Thus, it can be observed from the above table that implicit cost for all cells is less than the corresponding actual costs. Hence the improve solution is optimal and the minimum cost is Rs. 156 as under

Transportation cost

$F_1A = 11 \times 1 = 13$

$F_1B = ll \times 1 = 11$

$F_2B = 14 \times 2 \;=\; 28$

$F_2C = 12 \times 4 \;=\; 48$

$F_3A = 18 \times 2 \;=\; 36$

$F_3D = 12 \times 5 \;=\; \underline{60}$

Rs. $\underline{196}$

Problem 8. The Raja Company has two factories A and B located at some distance and three regional warehouse R, S, T. The transportation manager must schedule shipments for the coming week according to the following:

Warehouse R requires 70 tonnes

Warehouse S requires 60 tonnes

Warehouse T requires 50 tonnes

Capacity of factory A—100 tonnes

Capacity of factory B—200 tonnes

Transportation costs are as follows:

From factory A to warehouse	R — Rs. 30 per tonne
From factory A to warehouse	S — Rs. 10 per tonne
From factory A to warehouse	T — Rs.50 per tonne
From factory B to warehouse	R — Rs. 20 per tonne
From factory B to warehouse	S — Rs. 40 per tonne
From factory B to warehouse	T — Rs. 60 per tonne

Find the least cost shipping schedule.

Solution:

In the given problem, the total quantities available are 300 tonnes (100 tonnes in factory A and 200 tonnes in factory B) whereas the total requirements for all the three warehouses are only 180 tonnes (70 tonnes + 60 tonnes + 50 tonnes). So, it is a problem of unbalanced transportation. The total supply is larger than the surplus supply available. We can prepare the initial feasible table as follows by lowest cost entry method:

Initial feasible table by lowest cost entry method

Factory	Warehouse												Availability
	R			S			T			X			
A	30			10			50			0			100
					60			40					
			10			10			50			-10	
B	20			40			60			0			200
		70									120		
			20			20			60			4	
Required		70			60			50			(120)		300

In the above table it can be observed that m + n- 1 =5. It means 5 cells are occupied and the rule m + n - I is satisfied. Hence the solution is feasible.

In the above table, all implicit costs are either less or equal to the actual transportation cost hence this represents the optimal solution.

The least cost transportation schedule will be as follows:

	Rs.
From factory A to warehouse S : 40 tonnes @ 10 per tonne =	4,00
From factory A to warehouse T : 40 tonnes @ 50 per tonne =	2,000
From factory B to warehouse R : 70 tonnes @ 20 per tonne =	1,400
From factory B to warehouse T : 10 tonnes @ 60 per tonne =	600
Minimum total transportation cost =	4,400

4.2 Transportation

Transportation applications relate to a LPP where goods are to be transported from "m" production locations (factories) to "n" sales locations (warehouses). The objectives are (a) To meet the differing availabilities and requirements of these locations and (b) To minimise the total transportation costs.

The transportation application can be solved in three stages:

(a) Preliminary Check,

(b) Initial Basic Feasible Solution (IBFS),

(c) Optimality Test.

Methods of finding the initial basic feasible solution to a transportation problem:

IBFS can be determined using any of the following methods:

(a) Northwest Corner Rule,

(b) Least Cost Cell Method,

(c) Vogel's Approximation Method (VAM).

Sages involved in determining the solution to the Transportation Problem.

(1) Stage 1: Preliminary check involves the following:

(a) Verify Objective = Minimisation. In case of profit matrix, convert the same into an Opportunity Loss Matrix, by subtracting each number from the highest number in the matrix.

(b) Verify Nature of data = Balanced.

Data is said to be balanced if Total Availability = Total Requirement.

In case of unbalanced data, a dummy column or row should be introduced with zero transportation costs.

(2) Stage 2: IBFS can be determined using any of the following methods:

(a) Northwest Corner Rule,

(b) Least Cost Cell Method,

(c) Vogel's Approximation Method (VAM).

(3) Stage 3: Optimality Test: It consists of the following steps

(a) Computation of margin numbers, 'U' and 'V for all rows and columns such that U + V = Cost of allocated cells,

(b) Computation of U + V for unallocated cells,

(c) Computation of Cost Less (U + V) for unallocated cells, i.e. Step 1 minus Step 2 above.

Northwest Corner Rule in determining the IBFS.

Step	Procedures
1	▪ Ensure Availability = Requirement, by inserting dummy row or column, if required.
2	▪ Go to top left hand corner cell of the matrix
	▪ Compare availability and requirement.
	▪ Allocate availability or requirement, whichever is less, to that cell.
	▪ Cancel the row or column where availability or requirement is exhausted.
3	▪ Go to top left hand corner cell of the resultant matrix (after cancellation of row or column in Step 2)
	▪ Repeat Step 2 procedure till all the row availability and column requirements are satisfied.

Areas of Application:

Northwest Corner Rule may be used in transportation applications

- Within the campus of an organisation as cost differences are not significant.
- Obligations where cost is not the criteria for decision-making.

Least Cost Cell Method of determining the IBFS.

Step	Procedures
1	• Ensure Availability = Requirement, by inserting dummy row or column, if required.
2	• Identify the cell with the lowest cost. In case of a tie, arbitrary selection may be made. • Compare availability and requirement. • Allocate availability or requirement, whichever is less, to that cell. • Cancel the row or column where availability or requirement is exhausted.
3	• Identify the next lowest cell in the matrix. • Repeat Step 2 procedure till all the row availability and column requirements are satisfied.

Advantage: The cost associated with each route is taken into consideration. So, this method leads to a better allocation than North West Corner Rule Method.

Vogel's Approximation Method (VAM) for obtaining IBFS

Steps	Procedures
1	▪ Compute Cost Differences for each row and column. ▪ Cost Difference is the difference between the least cost and the next least cost in that row/column. ▪ In case of tie in least cost, Cost Difference = 0.
2	Ascertain the maximum of cost differences and select that row or column for allocation
3	Choose the least cost cell in the selected row or column for allocation.
4	▪ Compare availability and requirement for that cell. ▪ Allocate availability or requirement, whichever is less, to that cell. ▪ Cancel the row or column where availability or requirement is exhausted.
5	Compute Cost Differences for the resultant matrix and repeat the above procedure till all row availability and column requirements are satisfied.

Steps involved in Optimality Test:

Optimality test involves the following steps:

(1) Table 1: $U_i + V_j$ for allocated cells:

(a) Select the row/column with maximum number of allocations.

(b) For that row/column, U_i/V_j is equal to zero. [U_i for Rows; V_j for Columns]

(c) The other set of numbers U_i/V_j are computed in such a way that $U_i + V_j$ = Cost of allocated cells.

Note : The $U_i + V_j$ table can be completed only if the IBFS is non-degenerate.

IBFS is said to be degenerate if number of allocations < (No. of rows + No. of Columns - 1).

In case of degeneracy, a dummy allocation "e" (a number very close to zero) is made in the least cost unallocated cell falling in a non-dummy row or column.

(2) Table 2: $U_i + V_j$ for unallocated cells:

(a) Draw a matrix for the given rows and columns.

(b) Block out the allocated cells.

(c) Compute $U_i + V_j$ (total of margin numbers) for all unallocated cells.

(3) Table 3: Net Evaluation Table = Δ_{ij}

(a) Draw a matrix for the given rows and columns.

(b) Block out the allocated cells.

(c) Compute Cost Difference for all unallocated cells. Cost Difference = Number in Table (1) Less Number in Table (2).

Decision:

(a) If all numbers in the Net Evaluation Table are non-negative (i.e. > 0), IBFS is optimal and unique.

(b) If all numbers are positive and one of the cells contains zero, IBFS is optimal but not unique. Alternative solution exists. Total number of solutions = Number of Zeroes + 1

(c) If any one number in Table 3 is negative, solution is not optimal. Reallocation should be made to determine Alternative Basic Feasible Solution (ABFS).

(d) ABFS is tested for optimality by adopting the same procedure.

Concept of "loop" diagram in Transportation

(a) Identify the worst negative in Table 3. If there is a tie, choose the least cost cell.

(b) Draw a loop with the following principles:

- Loop should commence from and end in the selected worst negative cell.
- It should have only allocated cells as its other corners.
- Only horizontal and vertical lines (not diagonal) shall be permitted.
- Loop should result in a even sided figure.

(c) Identify the selected cell as having scope for allocation. It is marked with plus (+) sign.

(d) Other corners of the loop are identified with (-) and (+) signs alternatively.

(e) ABFS is determined by reference to reallocation as specified by the corners of the loop.

(f) Reallocation is done as under

- Identify the allocations to the negative cells (corners marked with (-) sign),
- Select the minimum out of the above allocations,
- Add this minimum to (+) corners and subtract this minimum from (-) corners,

  Other allocations remain unaffected.

(g) This ABFS is tested for optimality using the procedure outlined in the earlier question. In case negatives still arise in the Net Evaluation Table, the reallocation procedure should be continued further.

Treatment of different situations in the context of Transportation Problems:

Situation	Treatment
Total availability not equal to total requirement	• It is called unbalanced transportation application. • Introduce dummy row or column to balance availability and requirement. • All entries (costs) of the dummy row/column shall be zeroes.
Maximisation objective	• Select the highest element of profit in the matrix. • Subtract each element from the maximum element. • Take the resultant opportunity cost matrix with minimisation objective, for allocation procedure.

Situation	Treatment
Degeneracy	• Optimality test can be done only if number of allocations = [No. of rows + No. of Columns - 1] • If number of allocations is less, all U_i and V_j numbers cannot be computed. This situation is called degeneracy. • If IBFS is degenerate, introduce a dummy allocation (e), a small number very close to zero, in the least cost unallocated cell falling in a regular row or column. (i.e. non-dummy row or column)
Existence of zeroes in he Net Evaluation Table	• Zero in the Net Evaluation Table (Table 3) indicates the availability of alternative solutions. (provided all other numbers are positive) • The alternative optimal solutions can be determined by drawing a loop commencing from such cell having zero as net evaluation. • Reallocation will be based on the loop drawing procedure outlined above.
Prohibited routes	• Sometimes some routes may not be available due to reasons like bad road conditions, strike etc. • Such prohibited routes are identified with a high cost. represented by or "M", a very large cost close to infinity. • Due to assignment of very large cost, such routes would automatically be eliminated in the final solution.

Problems and Solutions

Problem 1.

A Company has four factories Fl, F2, F3 and F4 manufacturing the same product. Production and raw material costs differ from factory to factory and are given in the following table. The transportation costs from the factories to sales depots S1, S2 and S3 are also given. The sales price and the total requirement at each depot as also the product capacity at each factory is also stated. Determine the most profitable production and distribution schedule and the corresponding profit. The surplus production should be taken to yield zero profit.

Particulars	Fl	F2	F3	F4	Sales price per unit	Requirements per unit
Production Cost per unit	15	18	14	13		
Raw material Cost per unit	10	9	12	9		
Transportation cost per unit to						
S1	3	9	5	4	34	80
S2	1	7	4	5	32	120
S3	5	8	3	6	31	150
Production capacity (units)	10	150	50	100		

Solution:

From the data given, the profit matrix is constructed as follows:

Profit = Selling Price - Production Cost - Material Cost - Transportation Cost

Place	F -1	F - 2	F - 3	F - 4	Requirement
S - 1	6	-2	3	8	80
S - 2	6	-2	2	5	120
S - 3	1	- 4	2	3	150
Capacity	10	150	50	100	

- In the above matrix, the objective is maximization of profit. This is converted into a opportunity cost minimization objective by subtracting each element from the highest element i.e. 8.
- Also, the above matrix is unbalanced data since total Capacity is 310 units and total Requirement is 350 units. This is converted into balanced data by introducing the dummy factory F- 5 with zero as its entries.
- The revised matrix (balanced minimization) is given below.

Place	F -1	F - 2	F - 3	F - 4	F - 5	Requirement
S - 1	2	10	5	0	0	80
S - 2	2	10	6	3	0	120
S -3	7	12	6	5	0	150
Capacity	10	150	50	100	40	350

The above matrix is now amenable for applying VAM.

Initial Basic Feasible Solution (IBFS) is determined as under:

Place	F-1	F-2	F-3	F-4	F-5	Requirement	Cost Differences					
							I	II	III	IV	V	VI
S–1				**80**		80/0	0	2	—	—	—	—
	2	10	5	0	0							
S–2	**10**	**90**		**20**		120/110/90/0	2	1	1	**3**	4	10
	2	10	6	3	0							
S–3		**60**	**50**		**40**	150/110/60	**5**	1	1	1	**6**	12
	7	12	6	5	0							
Capacity	10/0	150/60/0	50/0	100/20/0	40/0	350						

Cost Diff:

I	0	0	1	3	0	In the above IBFS,
II	0	0	1	**3**	_	• Number of allocated cells is 7.
III	**5**	2	0	2	–	• m + n – 1 (i.e. Rows + Columns –1)= 3+ 5-1=7.
IV	_	2	0	2	_	
V	_	2	0	_	_	Hence, there is no degeneracy. This can
VI	–	2	_	–	–	be tested for optimality.

Note: Upon full allocation, the relevant row/column may be cancelled in pencil.

OPTIMALITY TEST:

Table 1 = $U_i + V_j$ for allocated cells computed as below:

$U_i + V_j$	2 – 0 = 2	10 – 0 = 10	6 – 2 = 4	3 – 0 = 3	0 – 2 = –2
0 –3 = –3	2	10	5	0 **80**	0
(base) = 0	2 **10**	10 **90**	6	3 **20**	0
12 – 10 = 2	7	12 **60**	6 **50**	5	0 **40**

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

–3+2 = –1	–3+10 = 7	–3+ 4 = 1		–3+(–2) = –5
		0 + 4 = 4		0 + (–2)= –2
2+2 = 4			2+3 = 5	

Table 3 = Net Evaluation Table (NET) = Table 1 - Table 2 for unallocated cells is computed below:

2– (–1) = 3	10 –7= 3	5 – 1= 4		0 – (–5) = 5
		6 – 4 = 2		0 – (–2)= 2
7 – 4 = 3			5 – 5 = 0	

Conclusion: Since all entries in NET are non-negative, the IBFS is optimal. Since one entry in NET is zero, the above optimal solution is not unique. One alternative solution exists.

Computation of Maximum Profit: (from the profit matrix formulated first)

Place	F – 1	F –2	F –3	F–4	F–5
S- 1				80 × 8 = 640	
S-2	10×6 = 60	90×(–2) = –180		20 × 5 = 100	
S-3		60×(–4) = –240	50 × 2 = 100		40 × 0 = 0

Determination of Alternative Optimal Solution: Since alternative solution is available, (one entry in NET = 0), the alternative optimal solution is determined by drawing a loop from the "Zero" entry in the NET. The loop is shown below in the NET of the IBFS.

2– (–1) = 3	10 –7= 3	5 – 1= 4		0 – (–5) = 5
	+ ve	6 – 4 = 2	– ve 20	0 – (–2)= 2
7 – 4 = 3	-ve 60		5 – 5 = 0 + ve	

Since the least allocation of the negative corners of the loop is 20, the alternative solution (optimal solution) determined by adding 20 to the positive corners, subtracting 20 from the negative corners and leaving the other cells undisturbed.

The alternative allocation is shown below:

2	10	5	0 **80**	0
2 **10**	10 **90 + 20=110**	6	3 **20**	0
7	12 **60 – 20 = 40**	6 **50**	5	0 **40**

The profit form the above alternative allocation is:

Place	F – 1	F – 2	F – 3	F – 4	F – 5
S–1				80 × 8 = 640	
S–2	10 × 6 = 60	110 × (–2) = – 220			
S–3		40 × (–4) = –160	50 × 2 = 100	20 × 3 = 60	40 × 0 = 0

Maximum Profit = Total of above = Rs.480

Note: The alternative solution need not be tested further for optimality, since the IBFS is already optimal.

Problem 2.

A company has three factories and four customers. It furnishes the following schedule of profit per unit on transportation of goods to customers in rupees. You are required to solve the transportation problem to maximize the profit. Determine the resultant optimal profit.

Factory / Customer	A	B	C	D	Supply
P	40	25	22	33	100
Q	44	35	30	30	30
R	38	38	28	30	70
Demand	40	20	60	30	

Solution: The above problem is profit maximization. Hence it should be converted into an opportunity loss matrix by subtracting the highest element i.e. 44 from the rest. Also the problem is unbalanced as demand = 150 and Supply = 200. Hence it should be balanced by introducing a dummy column with all entries as 0. Performing the above operations, the resultant balanced minimization matrix is -

Factory / Customer	A	B	C	D	E	Supply
P	4	19	22	11	0	100
Q	0	9	14	14	0	30
R	6	6	16	14	0	70
Demand	40	20	60	30	50	

Initial Basic Feasible Solution is determined as under:

Factory / Customer	A	B	C	D	E	Supply	Cost Differences			
							I	II	III	IV
A	**10**		**60**	**30**			4	7	7	7
	4	19	22	11	0	100/90/0				
B	**30**						0	**9**	–	–
	0	9	14	14	0	30/0				
C		**20**			**50**		**6**	0	0	–
	6	6	16	14	0	70/20/0				
Demand	40/10/0	20/0	60/0	30/0	50/0	200				

Cost Diff:

I	4	3	2	3	0	In the above IBFS,
II	4	3	2	3	–	• Number of allocated cells is 6.
III	2	**13**	6	3	–	• m + n- 1 (i.e. Rows + Columns- 1)
IV	4	–	2	11	–	= 3 + 5-1 = 7.
						Hence, there is a degeneracy.

To overcome degeneracy, a dummy allocation represented by 'e' (where 'e' = 0.00000.......1) is made in the least cost unallocated cell falling in a regular row or column i.e. non dummy row or column. [It should be noted that degeneracy does not make the IBFS as wrong answer; it is only a situation not a defect.]

OPTIMALITY TEST:

Table 1 = $U_i + V_j$ for allocated cells computed as below:

U_i & Vj	4 –0 = 4	6 – 2 = 4	22 – 0 = 22	11 – 0= 11	0 – 2 = – 2
(base) 0	**10**		**60**	**30**	
	4	19	22	11	0
0 – 4= –4	**30**				
	0	9	14	14	0
6 – 4 = 2	**e**	**20**			**50**
	6	6	16	14	0

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

	0 + 4 = 4			0+(–2) = –2
	– 4 + 4 = 0	– 4 + 22 = 18	– 4 + 11=7	– 4+ (–2) = – 6
		2 + 22 =24	2 + 11 = 13	

Table 3 = Net Evaluation Table (NET) = Table 1- Table 2 for unallocated cells is Table computed below:

	19–4 = 15			0–(–2) = 2
	9–0 = 9	14 – 18 = – 4	14 – 7 =7	0–(–6) = 6
		16 – 24 = – 8	14 –13 =1	

There are two negative elements in the NET, hence allocation is not optimal. The loop is created as below-

+ ve	19+4 = 15	– ve 60		0–(–2) = 2
	9 + 0 = 9	14 – 18 = –4	14 – 7 = 7	0–(–6) = 6
– ve 'e'		16–24 = –8	14 – 13 = 1	

ABFS 1: The new $U_i + V_j$ for allocated cells is computed from the above.

Table 1 = $U_i + V_j$ for allocated cells computed as below:

U_i & V_j	4 –0 = 4	6–(–6) =12	22– 0 = 22	11– 0 =11	0 – (–6) = 6
(base) 0	**10**		**60**	**30**	
	4	19	22	11	0
0 – 4 = – 4	**30**				
	0	9	14	14	0
16– 22 = – 6		**20**	**e**		**50**
	6	6	16	14	0

'e' is subtracted / added.

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

	0+ 12= 12			0 + 6 = 6
	– 4+12 = 8	–4 + 22 = 18	–4+11=7	–4 + 6 = 2
–6 + 4 = –2			–6+11=5	

Table 3 = Net Evaluation Table (NET) = Table 1 - Table 2 for unallocated cells is computed below -

	19–12 = 7			0 – 6 = –6
	9–8= 1	14–18 =–4	14–7 =7	0 – 2 = –2
6 –(–2) = 8			14–5 =9	

There are negative elements in the NET; hence allocation ABFS 1 is not optimal. The loop is created as below -

	19–12 = 7	– ve 60		0 – 6 = –6
	9–8= 1	14–18 = –4	14–7 =7	0 – 2 = –2
6 –(–2) = 8		+ ve	14–5 =9	– ve 50

ABFS 2 : The new $U_i + V_j$ for allocated cells is computed from the above.

Table 1 = $U_i + V_j$ for allocated cells computed as below:

U_i & V_j	4 – 0 = 4	6 – (–6) =12	22 – 0 = 22	11– 0 =11	0 – (0) = 0
(base) 0	**10**		**60**	**30**	**50**
	4	19	22	11	0
0 – 4 = –4	**30**				
	0	9	14	14	0
16–22= –6		**20**	**50**		
	6	6	16	14	0

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

	0 + 12 = 12			
	– 4 + 12 = 8	–4 + 22 = 18	–4 + 11 = 7	– 4 + 0 = –4
– 6 + 4 = –2			–6 + 11 =5	– 6 + 0 = – 6

Table 3 = Net Evaluation Table (NET) = Table 1 - Table 2 for unallocated cells is computed below:

	19 – 12 = 7			
	9 –8 = 1	14 – 18 = –4	14 –7 = 7	0 – (–4) = 4
6 –(–2) = 8			14 –5 = 9	0 – (–6) = 6

There are negative elements in the NET, hence allocation is not optimal. The loop is created as below:

+ ve	19 – 12 = 7			
– ve 30	9 –8 = 1	14 – 18 = –4	14 –7 = 7	0 – (–4) = 4
6 – (–2) = 8			14 –5 = 9	0 – (–6) = 6

ABFS 3: The new $U_i + V_j$ for allocated cells is computed from the above.

Table 1 = $U_i + V_j$ for allocated cells computed as below:

U_i & V_j	4 – 0 = 4	6– (–2) = 8	14 (–4) = 18	11– 0 =11	0 – 0 = 0
(base) 0	**20**			**30**	**50**
	4	19	22	11	0
0 – 4 = – 4	**20**		**10**		
	0	9	14	14	0
16 – 18 = -2		**20**	**50**		
	6	6	16	14	0

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

	0 + 8 = 8	0+18 = 18		
	– 4 + 8 = 4		– 4 + 11 = 7	– 4 + 0 = – 4
– 2 + 4 = 2			– 2 + 11 = 9	– 2 + 0 = – 2

Table 3 = Net Evaluation Table (NET) = Table 1- Table 2 for unallocated cells is computed below.

	19–8 = 11	22–18 = 4		
	9–4 = 5		14–7 =7	0 – (–4) = 4
6–2 = 4			14–9 = 5	0 – (–2) = 2

Since there are no non-negative elements in the NET, ABFS 3 is optimal and unique. Computation of Maximum Profit: (from the profit matrix formulated first)

Maximum Profit = Total of above = Rs.5130

Place	A	B	C	D	E
P	20 × 40 = 800			30×33=990	50×0 = 0
Q	20 × 44 = 880		10×30 = 300		
R		20 × 38 = 760	50×28= 1400		

Problem 3.

The information on the available supply to each warehouse, requirement of each market and the unit transportation cost from each warehouse to each market is given below:

Warehouse	Market				Supply
	Ml	M2	M3	M4	
A	5	2	4	3	22
B	4	8	1	6	15
C	4	6	7	5	8
Demand	7	12	17	9	

The shipping clerk has worked out the following schedule from his experience

Units	12	1	9	15	7	1
From warehouse	A	A	A	B	C	C
To – market	M2	M3	M4	M3	Ml	M3

You are required to-

(i) Check and see if the clerk has the optimal schedule

(ii) Find the optimal schedule and minimum total shipping cost and

If the clerk is approached by a carrier of route C to M2, who offers to reduce his rate in the hope of getting some business, by how much should the rate be reduced before the clerk considers giving him an order.

Solution:

Initial Basic Feasible Solution is determined as under from the data given above

Place	M-l	M-2	M-3	M-4	Requirement	Cost Differences					
						I	II	III	IV	V	VI
A		**12**	**1**	**9**							
	5	2	4	3							
B			**15**								
	4	8	1	6							
C	7		**1**								
	4	6	7	5							
Demand											

Cost Diff :

I	In the above IBFS,
II	• Number of allocated cells is 6.
III	• m + n-1 (i.e. Rows + Columns-1)
IV	= 3 + 4-1=6.
V	Hence, there is no degeneracy. This can be tested for
VI	optimality.

Cost Differences have not been computed since the Clerk's allocation is taken as the IBFS.

OPTIMALITY TEST:

Table 1 = $U_i + V_j$ for allocated cells computed as below:

U_i & V_j	4 – 7 = – 3	2 – 4= –2	0(base)	3 – 4= –1
4 – 0 = 4		**12**	**1**	**9**
	5	2	4	3
1 – 0= 1			**15**	
	4	8	1	6
7 –0 = 7	**7**		**1**	
	4	6	7	5

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

4 + (–3) = 1			
1 + (–3) = –2	1 + (–2) = –1		1 + (–1) = 0
	7 + (–2) = 5		7 + (–1) = 6

Table 3 = Net Evaluation Table (NET) = Table1-Table 2 for unallocated cells is computed below:

5 – 1=4			
4 –(–2) = 6	8 – (–l) = 9		6–0 = 6
	6 – 5 = 1		5–6 = –1

There is one negative element in the NET, hence scheduling by the clerk is not optimal. 1 is the least allocated to the negative corner. The loop is created as below -

5 – 1 = 4		+ ve	
4 – (–2) = 6	8 –(–l) = 9		6 – 0 = 6
	6 – 5 = 1	–ve	+ ve 5 – 6 = –l

ABFS 1: The new $U_i + V_j$ for allocated cells is computed from the above.

Table 1 = $U_i + V_j$ for allocated cells computed as below:

U_i & V_j	4–2 = 2	2–0 = 2	4–0 = 4	3–0 = 3
(base) 0		**12**	**1+1 = 2**	**9–1=8**
	5	2	4	3
1 – 4 = –3			**15**	
	4	8	1	6
5 – 3 = 2	**7**			**0+1=1**
	4	6	7	5

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

0 + 2 = 2			
– 3+2 = –1	–3 + 2 = –1		–3 + 3 = 0
	2 + 2 = 4	2 + 4 = 6	

Table 3 = Net Evaluation Table (NET) = Table 1 - Table 2 for unallocated cells is computed below:

5 – 2 = 3			
4 – (–l) = 5	8 – (–l) = 9		6 – 0 = 6
	6 – 4 = 2	7 – 6=1	

All elements in the NET are non-negative; hence the revised allocation is optimal and unique.

The optimal allocation and cost is -

Place	M–l	M–2	M–3	M–4
A		12×2 = 24	2×4 = 8	8 × 3 = 24
B			15× 1 = 15	
C	7×4 = 28			1 ×5 = 5

Minimum Cost - Total of above = Rs.104

If the clerk wants to consider the carrier of route C to M - 2 for giving an order, then this transportation cost should be less than the carrier of routes C to M - 1 and C to M - 4 (which are presently allocated cells / routes.) Hence the carrier of route C to M - 4 has to bring down his rate to Rs.3 from the present Rs.6.

Problem 4.

X Company is interested in taking loans from banks for its projects — P, Q, R, S, T. The rates of interest and the lending capacity differ from bank to bank. All these projects are to be completed. The relevant details are provided below. Assuming the role of a consultant, advice the Company as to how it should take the loans so that the total interest payable is least. Find out alternate optimum solutions, if any.

Source Bank	Interest rate in % for projects					Max Credit
	P	Q	R	S	T	(in 000s)
Private Bank	20	18	18	17	17	Any amount
Nationalised Bank	16	16	16	15	16	400
Co-operative Bank	15	15	15	13	14	250
Amount required (in 000s)	200	150	200	125	75	

Solution.

Total amount required as loan = Rs.750 (000s). The private bank can give any amount. The data is made balanced by putting 100 against the private bank.

Initial Basic Feasible Solution is determined as under:

Part.	P	Q	R	S	T	Amount	Cost Differences					
							I	II	III	IV	V	VI
		100										
Private	20	18	18	17	17	100/0	0	1	0	0	0	18
	150	**50**	**200**									
National	16	16	16	15	16	400/250/50/0	1	0	0	0	0	16
	50			**125**	**75**							
Co-op	15	15	15	13	14	250/125/50/0	1	1	0	–	–	–
Requ-ired	200/150/0	150/0	200/0	125/0	75/0	750						

Cost Diff:						
I	1	1	1	**2**	2	In the above IBFS,
II	1	1	1	–	**2**	• Number of allocated cells is 7.
III	1	1	1	_	–	• m + n - 1 (i.e. Rows + Columns - 1)
IV	**4**	2	2	–	–	= 3 + 5–1=7.
V	–	2	**2**	–	–	Hence, there is no degeneracy.
VI	–	2	–	–	–	This can be tested for optimality.

Optimality Test:

Table 1 = $U_i + V_j$ for allocated cells computed as below:

U_i & V_j	15–0=15	16–1 = 15	16–1 = 15	13–0= 13	14–0=14
18–15=3		**100**			
	20	18	18	17	17
16–15 = 1	**150**	**50**	**200**		
	16	16	16	15	16
(base) 0	**50**			**125**	**75**
	15	15	15	13	14

Table 2 = $U_i + V_j$ for unallocated cells computed as below:

3 + 15 = 18		3 + 15 = 18	3 + 13 = 16	3+ 14=17
			1 + 13 = 14	1 + 14= 15
	0 + 15 = 15	0 + 15=15		

Table 3 = Net Evaluation Table (NET) = Table 1 - Table 2 for unallocated cells is computed below:

20–18 = 2		18–18 = 0	17–16= 1	17–17 = 0
			15–14= 1	16–15 = 1
	15–15 = 0	15–15 = 0		

Solution is optimal since all elements in NET are non-negative. However there are four zeroes and so the solution is not unique. There are four alternate solutions.

Computation of Minimum Cost: (amounts in '000s and interest rate in %)

Particulars	P	Q	R	S	T
Private		100× 18= 18			
National	150×16 =24.00	50× 16 = 8	200×16= 32		
Co-op	50×15 = 7.50			125×13= 16.25	75×14= 10.50

Minimum Cost = Total of above = Rs.l,16,250

Determination of Alternative Optimal Solution -1:

The alternative optimal solution is determined by drawing a loop from the "Zero" entry in the NET. The loop is shown below in the NET of the IBFS.

20 – 18 = 2	– ve 100	18 – 18 = 0	17 – 16 = 1	17 – 17 = 0
	+ ve	– ve	15 – 14 = 1	16 – 15 = 1
	15 – 15 = 0	15 – 15 = 0		

Since the least allocation of the negative corners of the loop is 100, the alternative solution (optimal solution) is determined by adding 100 to the positive corners, subtracting 100 from the negative corners and leaving the other cells undisturbed.

The alternative allocation is shown below:

	100 – 100 = 0	0 + 100 = 100		
20	18	18	17	17
150	50 + 100 = 150	200 - 100 = 100		
16	16	16	15	16
50			125	75
15	15	15	13	14

The cost from above alternative re-allocation is :

Particulars	P	Q	R	S	T
Private			100 x 18 =18.00		
National	150 x 16 = 24.00	150 x 16 = 24.00	200 x 16=32.00		
Co- op	50 x 15 = 7.50			125 x 13 = 16.25	75 x 14 = 10.50

Minimum Cost = Total of above = Rs.1,16,250

Determination of Alternative Optimal Solution 3: The alternative optimal solution is determined by drawing a loop from the "Zero" entry in the NET. The loop is shown below in the NET of the IBFS.

20 – 18 = 2		18 – 18 = 0	17 – 16 = 1	17 – 17 = 0
+ ve	**+ ve**		15 – 14 = 1	16 – 15 = 1
– ve50	15 – 15 = 0	15 – 15 = 0		

Since the least allocation of the negative corners of the loop is 50, the alternative solution (optimal solution) is determined by adding 50 to the positive corners, subtracting 50 from the negative corners and leaving the other cells undisturbed.

The alternative allocation is shown below:

	100			
20	**18**	**18**	**17**	**17**
150 + 50 = 200	**50–50=0**	**200**		
16	**16**	**16**	**15**	**16**
50 – 50 = 0	**0 + 50 = 50**		**125**	**75**
15	**15**	**15**	**13**	**14**

The cost from the above alternative re-allocation is :

Particulars	P	Q	R	S	T
Private		100 x 18 = 18.00			
National	200 x 16 = 32.00		200 x 16 = 32.00		
Co-op		50 x 15 = 7.50		125 x 13 = 16.25	75 x 14 = 10.50

Minimum Cost = Total of above = Rs.l, 16,250

Determination of Alternative Optimal Solution - 3: The alternative optimal solution is determined by drawing a loop from the "Zero" entry in the NET. The loop is shown below in the NET of the IBFS

20 – 18 = 2		18 – 18 = 0	17 – 16 = 1	17 – 17 = 0
+ve		– ve200	15 – 14 = 1	16 – 15 = 1
– ve50	15 – 15 = 0	15 – 15 = 0		

Since the least allocation of the negative corners of the loop is 50, the alternative solution (optimal solution) is determined by adding 50 to the positive corners, subtracting 50 from the negative corners and leaving the other cells undisturbed.

	100			
20	**18**	**18**	**17**	**17**
150 + 50 = 200	**50**	**200 – 50 = 150**		
16	**16**	**16**	**15**	**16**
50 – 50 = 0		**0 + 50 = 50**	**125**	**75**
15	**15**	**15**	**13**	**14**

The cost from above alternative re-allocation is :

Particulars	P	Q	R	S	T
Private		100 x 18 = 18.00			
National	200 x 16 = 32.00	50 x 16 = 8.00	150 x 16=24.00		
Co- op			50 x 15 = 7.50	125 x 13 = 16.25	75 x 14 = 10.50

Minimum Cost = Total of above = Rs.l,16,250

Determination of Alternative Optimal Solution - 4:]

The alternative optimal solution is determined by drawing a loop from the "Zero" entry in the NET. The loop is shown below in the NET of the IBFS.

20 – 18 =2	**– ve 100**	18 – 18 = 0	17 – 16 = 1	17 – 17 = 0
– ve 150	**+ ve**		15 – 14 = 1	16 – 15 = 1
+ ve	15 – 15 = 0	15 – 15 = 0		**- ve = 75**

Since the least allocation of the negative corners of the loop is 75, the alternative solution (optimal solution) is determined by adding 75 to the positive corners, subtracting 75 from the negative corners and leaving the other cells undisturbed.

	100 - 75 = 25			**0 + 75 = 75**
20	**18**	**18**	**17**	**17**
150 - 75 = 75	**50 + 75 = 125**	**200**		
16	**16**	**16**	**15**	**16**
50 + 75 = 125			**125**	**75 - 75 = 0**
15	**15**	**15**	**13**	**14**

The cost from the above alternative re-allocation is :

Particulars	P	Q	R	S	T
Private		25 x 18 = 4.50			75 x 17 = 12.75
National	75 x 16 = 12.00	125 x 16 = 20.00	200 x 16 = 32.00		
Co-op	125 x 15 = 18.75			125 x 13 = 16.25	

Minimum Cost = Total of above = Rs. 1,16,250

4.3 Replacement of Machine and other Relevant Concept

Replacement of Machines and Equipment

Machines are purchased and replacement of old machines-are made mainly for two reasons:

1. To increase the productive capacity and
2. To reduce cost of production.

Various other reasons for replacement are the following,

1. To get rid of worn out, broken down or obsolete machines,
2. To accommodate larger sizes of work and increase the machine capacity,
3. To reduce labour cost by introducing semi-automatic machines or machines more than one of which can be operated by a single operator,
4. To simplify operations by using automatic machines which are capable of performing variety of work usually performed by a number of different machines,
5. To minimise repair cost and reduce idle time.

An analysis of the above six reasons will lead to either increase in capacity or reduction in cost or both.

Factors on which equipment is replaced: The replacement plan depends on evaluation of present and replacement machines from the point of view of technical suitability and cost saving features.

The points to check for replacement studies vary from industry, to industry on management conditions and management policies. But some factors are common to practically all cases. These are:

Technical Factors:

(i) Inadequacy from the stand paint of range, speed, accuracy, strength, rigidity, output and capacity,

(ii) Obsolescence and equipment worn out condition,

(iii) Special advantage of the new machine as to easiness of set ups convenience of operation, safety, reliability performance, control panels and special features,

(iv) Flexibility and versatility of the machine.

Cost Factors:

(i) High repair cost of existing machine,

(ii) High remodelling cost of existing machine,

(iii) Less chance of spoilage and rejection work causing: saving in cost,

(iv) Faster rate of production causes lower cost,

(v) Replacement of skilled -workers by semi-skilled and: unskilled workers leading to lesser labour cost,

(vi) Compactness of the machine leading to a saving in-space which means saving of overhead costs,

(vii) Machine pay back period i.e. how soon the cost of the equipment is recovered,

(viii) Life of the new machine giving effective service,

(ix) Flexibility and versatility of the machine tending to reduce idle time cost with changes in methods of production-which might occur in future,

(x) Availability of funds for the acquisition of the equipment or possibility of special arrangement like hire-purchase or government loans or other accommodations.

Replacement Programmes: It is prudent to have phased .policies of machine replacement plans than to wait until breakdowns occur causing production hold ups. There are different forms of the programme.

1. A definite amount of money or a certain percentage of earning of the company is used each year to replace existing machines which are either superseded by improved models or are not in tip top condition or are having insufficient capacity.

2. Replacement is made of the oldest or most inadequate machine each year by upto date machines of greater accuracy or higher capacity. Some times automatic machines are gradually introduced in this way which is capable of doing several operations with lesser number of operators.

3. The economy of working on various machines are studied .and replacement of machines are made only to have a definite cost reduction.

Whatever may be the programme, replacement question is to be carefully considered in prosperous and normal years only. In slum or dull periods, replacement should not be done unless it is unavoidable.

The basic concept of 'Replacement Theory' is to take decision about the time when an item of 'Capital Asset' should be replaced by another of the same type or by a different one. In other words 'Replacement Theory' concerns about 'optimum period of replacement'.

For the purpose of 'Replacement Theory' Capital equipment are basically divided under two broad categories:

1. Replacement policy for Equipment which detoriates with time gradually;

2. Items which fail suddenly and cannot be made workable by incurring repairing costs.

Again, replacement of Capital equipment which gradually detoriates with time, can be worked-out under two different ways:

(i) Ignoring the concept of time value of money and considering the time value of money.

(ii) When time value of money is not considered: Determination of optimum period of 'Replacement' Let us, consider the following formula:

$$T(r) = C - S + \sum_{t=1}^{r} Mt$$

where, T(r) denotes owning and maintaining cost of keeping an equipment for 'r years'

C = Capital cost of the equipment

S = Salvage value of the equipment at the end of 'r years'

Mt = Cost of maintenance in year t

Accordingly, the average cost, A(r) can be calculated as under:

$$A(r) = \frac{1}{r}\left[C - S + \sum_{T=1}^{r} Mt\right]$$

Decision: When to replace? The optimal replacement period would be the year, in which A(r) = Average cost is minimum.

(ii) When time value of money is considered: In this case the concept of present value of money is considered. Considering the interest rate, which is also termed as discounting factor or discounting rate with that the present values of maintenance costs are to be evaluated for each year and final annualised cost, for different years are also evaluated. Decision: When to replace? The decision will be taken by considering the following rules:

A. Replacement will not be made if annualised cost > next period's cost.

B. Replacement will be made in that year only, when annualised cost < next period's cost. In other words, replacement will be made every r years.

when A(r) = the annualized cost of replacing every r years is the minimum.

Important Assumptions

(a) Salvage/scrap value of the equipment to be replaced should be considered as 'nil'

(b) The maintenance costs are assumed to be incurred at the beginning of the year.

Replacement of items which fail suddenly

Sometimes, the failure of an item may cause a complete breakdown of the system. The costs of failure, in such a case will be quite higher than the cost of the item itself. So, it is important to know in advance as to when the failure is likely to take place so that item can be replaced before it actually fails and the time of failure can be predicted from the probability distribution of failure time obtained from past experience and then, to find the optimal value of time t which minimises the total cost involved in the system. Mainly two types of replacement policies are there:

(1) Individual replacement policy in which an item is replaced immediately after it fails.

(2) Group replacement policy in which all items are replaced, irrespective of whether they have failed or not, with a provision that if any item fails before the optimal time, it may be individually replaced.

Let us, explain through example how 'Replacement of items which fail suddenly' is considered: Following failure rates have been observed for a certain type of light bulbs:

Week:	1	2	3	4	5
Per cent failing by the end of week:	10	25	50	80	100

There are 1,000 bulbs in use, and it costs Rs. 2 to replace an individual bulb which has burnt out. If all bulbs were replaced simultaneously it would cost 50 paisa per bulb. It is proposed to replace all bulbs at fixed intervals of time, whether or not they have burnt out, and to continue replacing burnt out bulbs as and when they fail. At what intervals all the bulbs should be replaced? At what group replacement price per bulb would a policy of strictly individual replacement become preferable to the adopted policy?

Solution: Let, P_i be the probability that a light bulb, which was new when placed in position for use, fails during the ith week of its life.

Thus, following frequency distribution is obtained assuming to replace burnt out bulbs as and when they fail,

P_1 = the prob. of failure in Ist week = (10/100)	= 0.10
P_2 = the prob. of failure in IInd week = (25 - 10/100	= 0.15
P_3 = the prob. of failure in IIIrd week = (50 - 25)/100	= 0.25
P_4 = the prob. of failure in IVth week = (80 - 50)/100	= 0.30
P_5 = the prob. of failure in Vth week = (100 - 80)/100	= 0.20
Total	= 1.00

Since the sum of all probabilities can never be greater than unity, therefore all further probabilities P_6, P_7 and P_8 so on, will be zero. Thus, a bulb that has already lasted four weeks is sure to fail during the fifth week. Furthermore, assume that

(i) Bulbs that fail during a week are replaced just before the end of that week, and

(ii) The actual percentage of failures during a week for a subpopulation of bulbs with the same age is the same as the expected percentage of failures during the week for that subpopulation.

Let N_i be the number of replacements made at the end of the ith week, if all 1000 bulbs are new initially. Thus,

$$N_0 = N_0 \qquad = 1{,}000$$
$$N_1 = N_0p_1 = 1{,}000 \times 0.10 \qquad = 100$$
$$N_2 = N_0p_2 + N_1p_1 = 1{,}000\times0.15 + 100\times0.10 \qquad = 160$$
$$N_3 = N_0P_3 + N_1p_2 + N_2p_1 = 1{,}000\times0.25 + 100\times0.15 + 160\times0.10 \qquad = 281$$
$$N_4 = N_0p_4 + N_1p_3 + N_2P_2 + N_3p_1 \qquad = 377$$
$$N_5 = N_0p_5 + N_1p_4 + N_2P_3 + N_3p_2 + N_4p_1 \qquad = 350$$
$$N_6 = 0 + N_1p_5 + N_2p_4 + N_3p_3 + N_4p_2 + N_5p_1 \qquad = 230$$
$$N_7 = 0 + 0 + N_2p_5 + N_3p_4 + N_4p_3 + N_5p_2 + N_6p_1 \qquad = 286$$

and so on.

It has been observed that the expected number of bulbs burnt out in each week increases until 4^{th} week and then decreases until 6th week and again starts increasing. Thus, the number will continue to oscillate and ultimately the system settles down to a steady state in which the proportion of bulbs failing in each week is the reciprocal of their average life.

Since the mean age of bulbs

$$= 1\times p_1 + 2\times p_2 + 3\times p_3 + 4\times p_4 + 5\times p_5$$

$$= 1 \times 0.10 + 2 \times 0.15 + 3 \times 0.25 + 4 \times 0.30 + 5 \times 0.20 = 3.35 \text{ weeks.}$$

the number of failures in each week in steady state becomes

= 1,000/3.35 = 299 and the cost of replacing bulbs only on failure = 2 × 299 (at the rate of Rs. 2 per bulb) = Rs. 598.

Since the replacement of all 1,000 bulbs simultaneously costs 50 paise per bulb and replacement of an individual bulb on failure costs Rs. 2, therefore cost of replacement of all bulbs simultaneously is as given in the following table:

End of week	Cost of individual replacement	Total cost of group replacement	Average cost per week
1	100 × 2 = 200	1,000 × 0.50 +100×2 = Rs.700	Rs. 700.00
2	160× 2 = 320	700+ 160×2 = Rs. 1,020	Rs.510.00
3	281 ×2 = 562	1,020 + 281 ×2 = Rs. 1,582	Rs. 527.33

The cost of individual replacement in the third week exceeds the average cost for two weeks.

Thus it would be optimal to replace all the bulbs after every two weeks; otherwise the average cost will start increasing.

Further, since the group replacement after one week costs Rs. 700 and the individual replacement after one week costs Rs. 598, the individual replacement will be preferable.

Replacement—Staffing Problem

Problems concerning recruitment and promotion of staff can sometimes be analysed in a manner similar to that used in replacement problems in industry.

A faculty in a college is planned to rise to strength of 50 staff members and then to remain at that level. The wastage of recruits depends upon their length of service and is as follows:

Year:	1	2	3	4	5	6	7	8	9	10
Total % who left up to:	5	35	36	65	70	76	80	86	95	100

the end of year

(i) Find the number of staff members to be recruited every year.

(ii) If there are seven posts of Head of Deptt. for which length of service is the only creterion of promotion, what will be average length of service after which a new entrant should expect promotion?

Solution:

Let us assume that the recruitment per year is 100. From above it is clear that the 100 who join in the first year will become zero in 10th year, the 100 who join in the 2nd year will (serve for 9 years and) become 5 at the end of the 10th year and the 100 who join in the 3rd year will (serve or 8 years and) become 14 at the end of the 10th year and so on. Thus, when the equilibrium is attained, the distribution length of service of staff members will be as under:

Year	No. of staff members
0	100
1	95
2	65
3	44
4	35
5	30
6	24
7	20
8	14
9	5
10	0
Total	432

(i) Thus if 100 staff members are recruited every year, the total number of staff members after 10 years of service = 432

100 To maintain a strength of 50, the number to be recruited every year = $\frac{100}{432}$ x 50 = 11.6

It is assumed that those staff members who completed x years' service but left before x + 1 years' service, actually left immediately before completing x + 1 years.

If it is assumed that they left immediately after completing x years' service, the total number will become 432 - 100 = 332 and 100 the required intake will be 50 x $\frac{100}{332}$ = 15

In actual practice they may leave at any time in the year so that reasonable number of recruitments per year = $\frac{11.6+15}{2}$ = 13 (approx)

(ii) If we recruit 13 persons every year then we want 7 seniors. Hence if we recruit 100 every year, we shall require $\frac{7}{13}$ x 100 = 54 (approx.) seniors.

It can be seen that 54 seniors will be available if we promote them during 6th year of their service ($\because$ 0 + 5 + 14 + 20 + 24 = 63 > 54).

$\therefore$ The promotion of a newly recruited staff member will be due after completing 5 years and before putting in 6 years of service.

$\therefore$

Problems and Solutions

Problem : 1. The following table gives the running costs per year and resale values of a certain equipment whose purchase price is Rs. 6,500. At what year is the replacement due optimally.

Year	1	2	3	4	5	6	7	8
Running costs (Rs.)	1,400	1,500	1,700	2,000	2,400	2,800	3,300	3,900
Resale value (Rs.)	4,000	3,000	2,200	1,700	1,300	1,000	1,000	1,000

Problem: 2. A truck-owner finds from his past experience that the maintenance costs are Rs. 200 for the first year and then increase by Rs. 2,000 every year. The cost of the Truck Type A is Rs. 9,000. Determine the best age at which to replace, i.e. truck. If the optimum replacement is followed what will be the average yearly cost of owing and operating the Truck? Truck Type B cost Rs. 10,000. Annual operating costs are Rs. 400 for the first year and then increase by Rs. 800 every year. The Truck owner have now the Truck Type A which is one year old. Should it be replaced with B type, and if so, when?

Problem:3. A Plant Manager is considering replacement policy to a new machine. He estimates the following costs:

Year	1	2	3	4	5	6
Replacement cost at the beginning of the year	100	110	125	140	160	190
Salvage value at the end of the year	60	50	40	25	10	0
Operating costs	25	30	40	50	65	80

Find the year when replacement is to be made.

Problem : 4. A fleet owner finds from his past records that the costs per year of running a vehicle whose purchase price is Rs 50,000 are as under:

Year	1	2	3	4	5	6	7
Running cost Rs.)	5,000	6,000	7,000	9,000	11,500	16,000	18,000
Resale value (Rs.)	30,000	15,000	7,500	3,750	2,000	2,000	2,000

Thereafter, running cost increases by Rs. 2,000, but resale value remains constant at Rs. 2,000. At what age is a replacement due?

Problem : 5. The following mortality rates have been observed for a certain type of light bulbs:

Week	1	2	3	4	5
Per cent failing by end of week	10	25	50	80	100

There are 1,000 bulbs in sue, and it costs Rs. 2 to replace an individual bulb which has burnt out. If all bulbs were replaced simultaneously it would cost 50 paise per bulb. It is proposed to replace all bulbs at fixed intervals, whether or not they have burnt out, and to continue replacing burnt out bulbs as they fail. At what intervals should all the bulbs be replaced?

Problem : 6. An electric company which generates and distributes electricity conducted a study on the life of poles. The repatriate life data are given in the following table:

Life data of electric poles

Years after installation:	1	2	3	4	5	6	7	8	9	10
Percentage poles failing:	1	2	3	5	7	12	20	30	16	4

(i) If the Company now installs 5,000 poles and follows a policy of replacing poles only when they fail, how many poles are expected to be replaced each year during the next ten years?

To simplify the computation assume that failures occur and replacements are made only at the end of a year.

(ii) If the cost of replacing individually is Rs. 160 per pole and if we have a common group replacement policy it costs Rs. 80 per pole, find out the optimal period for group replacement.

Problem : 7. A manufacturer is offered two machines A and B. A is priced at Rs. 5,000 and running costs are estimated Rs. 800 for each of the first five years, increasing by Rs. 200 per year in the sixth and subsequent year. Machine B, which has the same capacity as A, costs Rs. 2,500 but will have running costs of Rs. 1,200 per year for six years, increasing by Rs. 200 per year thereafter.

If money is worth 10% per year, which machine should be purchased? (Assume that the machines will eventually be sold for scrap at a negotiable price).

Problem: 8. Suppose that a special purpose type of light bulb never lasts longer than 2 weeks. There is a chance of 0.3 that a bulb will fail at the end of the first week. There are 100 new bulbs initially. The cost per bulb for individual replacement is Re. 1 and the cost per bulb for a group replacement is Re. 0.50. It is cheapest to replace all bulbs: (i) individually, (ii) every week, (iii) every second week, (iv) every third week?

Problem: 9. A manufacturing firm is considering a policy of replacing certain key electrical components belonging to one group of machines on a group replacement basis instead of making repairs as needed. There are approximately 100 parts of one type that have the mortality distribution shown below. The cost of replacing parts on individual basis is estimated to be Rs. 10 per part whereas that on group basis comes to Rs. 3 per part. Compare the average weekly cost of the two replacement alternatives:

Week	Probability of failure during week
1	0.3
2	0.1
3	0.1
4	0.2
5	0.3

***Solution 1*:** Chart showing optimal Replacement period

∴

Year	Net capital cost (Rs.) (C–S)	Running Cost (Rs.)	Cumulative running cost (Rs.)	Total cost Rs. (2) + (4)	Average Annual cost (Rs.) (5)÷(1)
(1)	(2)	(3)	(4)	(5)	(6)
1	2,500	1,400	1,400	3,900	3,900
2	3,500	1,500	2,900	6,400	3,200
3	4,300	1,700	4,600	8,900	2,967
4	4,800	2,000	6,600	11,400	2,850
5	5,200	2,400	9,000	14,200	2,840
6	5,500	2,800	11,800	17,300	2,882

∴ Optimal replacement period at the end of 5^{th} year.

Solution 2 **Truck A Chart Showing Optimal Replacement Period**

Year (1)	Capital cost (Rs.) (2)	Maintenance cost (Rs.) (3)	Cumulative maintenance cost (Rs.) (4)	Total cost (Rs.) (5) (2) + (4)	Avg. annual cost (Rs.) (6) (5) ÷ (1)
1	9,000	200	200	9,200	9,200
2	9,000	2,200	2,400	11,400	5,700
3	9,000	4,200	6,600	15,600	5,200
4	9,000	6,200	12,800	21,800	5,450

∴ Optimal replacement period end of 3rd year.

Truck B Chart Showing Optimal Replacement Period

Year	Capital cost (Rs.)	Maintenance cost (Rs.)	Cumulative maintenance cost (Rs.)	Total cost (Rs.)	Avg. annual cost (Rs.)
(1)	(2)	(3)	(4)	(2) + (4)	(5) ÷ (1)
1	10,000	400	400	10,400	10,400
2	10,000	1,200	1,600	11,600	5,800
3	10,000	2,000	3,600	13,600	4,533
4	10,000	2,800	6,400	16,400	4,100
5	10,000	3,600	10,000	20,000	4,000
6	10,000	4,400	14,400	24,400	4,067

Comparing the average cost of Trucks A and B when the current truck A is one year old.

Average Annual Maintenance Cost

Year	A	B
1	5,700	10,400
2	5,200	5,800
3	5,450	4,533

At the year third, the Truck A can be replaced by Truck B and subsequently it can be replaced at the end of 5 years of its use.

Solution 3.

Chart Showing Optimal Replacement Period

Year	Net capital cost (Rs.) (Cost - Scrap)	Operation cost (Rs.)	Cumulative operation Costs (Rs.)	Total cost (Rs.)	Average annual cost (Rs.)
1	40	25	25	65	65
2	60	30	55	115	57.5*
3	85	40	95	180	60
4	115	50	145	260	65
5	150	65	210	360	72
6	190	80	290	480	80

The asset should be replaced by the end of 2nd year where the average annual cost is lowest.

Solution 4.

Chart Showing Optimal Replacement Period

Year (1)	Net capital cost (Rs.) (2)	Annual maintenance cost (Rs.) (3)	Cumulative operation costs (Rs.) (4)	Total cost (Rs.) (5)	Average annual cost (Rs.) (6) (5) ÷ (1)
1	20,000	5,000	5,000	25,000	25,000
2	35,000	6,000	11,000	46,000	23,000
3	42,500	7,000	18,000	60,500	20,167
4	46,250	9,000	27,000	73,250	18,313
5	48,000	11,500	38,500	86,500	17,300
6	48,000	16,000	54,500	1,02,500	17,083*
7	48,000	18,000	72,500	1,20,500	17,214

Otimal replacement at the end of 6th year.

Solution 5.

Chart Showing Optimal Replacement Period

	1	2	3	4	5
% failing during the week	10	15	25	30	20

Initial cost = 1000 x .5 = 500

Week	Bulbs to be replaced cost	Weekly cost	Cumulative cost	Total cost	Avg. Weekly cost
1	1,000 × 0.1 = 100	200	200	700	700
2	1,000 ×0.15 + 100 × 0.1 = 160	320	520	1,020	510
3	1,000×0.25+100×0.15+160 ×0.10 = 281	562	1,082	1,582	527

It should be replaced by the end of Second Week.

Solution 6.

Chart Showing Optimal Replacement Period

Average life of the pole $1 \times 0.01 + 2 \times 0.02 + 3 \times 0.03 + 4 \times 0.05 + 5 \times 0.07 + 6 \times 0.12 + 7 \times 0.20 + 8 \times 0.3 + 9 \times 0.16 + 10 \times 0.04 = 7.05$

No. of poles to be replaced every year $= \dfrac{5000}{7.05} = 709$

Average yearly cost on individual replacement = 709×160 = Rs. 1,13,440.

Group Replacement: Initial Cost = 5,000 × 80 = 4,00,000

Year	No. of poles to be replaced	Yearly cost	Cumulative cost	Total cost	Avg.annual cost
1	5000 × 0.01 = 50	8,000	8,000	40,8000	40,8000
2	5000 × 0.02 +50 ×.01 = 101	16,160	24,160	42,4160	21,2080
3	5000 × 0.03+50 × 0.02 +101× 0.01= 152	24,320	48,480	44,8480	14,9493
4	5000 × 0.05 + 50 × 0.03+ 101× 0.02+152 × 0.01 = 256	40,960	89,440	48,9440	12,2360
5	5,000 × 0.07 + 50 × 0.05 + 101 × 0.03 + 152 × 0.02 + 265 × 0.01 = 362	57,920	1,47,360	5,47,360	1,09,472
6	5,000 × 1.2 + 50 × 0.07 + 101 × 0.05 + 152 × 0.03 + 256 × 0.02 + 362 × 0.01 = 6023	9,63,680	11,11,040	15,11,040	2,51,840

Optimal replacement at the end of the 5th year.

Solution 7.

Machine A: Chart Showing Optimal Replacement Period

Year	Running cost (Rs.)	Discount factor	Discounted running Cost (Rs.)	Cumulative running Cost (Rs.)	Total cost (Rs.)	Cumulative discounted factor	Annualized cost (Rs.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) = (6) ÷7
1	800	1.00	800	800	5,800	1.00	5,800
2	800	0.9091	727	1,527	6,527	1.9091	3,419
3	800	0.8264	661	2,188	7,188	2.7355	2,628
4	800	0.7513	601	2,789	7,789	3.4868	2,234
5	800	0.6830	546	3,335	8,335	4.1698	1,999
6	1,000	0.6209	621	3,956	8,956	4.7907	1,869
7	1,200	0.5645	677	4,633	9,633	5.3552	1,799
8	1,400	0.5132	718	5,351	10,351	5.8684	1,764
9	1,600	0.4665	746	6,097	11,097	6.3349	1,752
10	1,800	0.4241	763	6,860	11,860	6.7590	1,755

Machine B:

Chart showing optimal Replacement period

Year	Running cost (Rs.)	Discount factor	Discounted running Cost (Rs.)	Cumulative running Cost (Rs.)	Total cost (Rs.)	Cumulative discounted factor	Annualized cost (Rs.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)=6÷7
1	1,200	1.00	1,200	1,200	3,700	1.0000	3,700
2	1,200	0.9091	1,091	2,291	4,791	1.9091	2,510
3	1,200	0.8264	992	3,283	5,783	2.7353	2,114
4	1,200	0.7513	902	4,184	6,684	3.4868	1,917
5	1,200	0.6830	820	5,004	7,504	4.1698	1,800
6	1,200	0.6209	745	5,750	8,250	4.7907	1,722
7	1,400	0.5645	790	6,540	9,040	5.3552	1,688
8	1,600	0.5132	821	7,361	9,861	5.8684	1,680
9	1,800	0,4665	840	8,201	10,701	6.3349	1,689

Machine B should be purchased as its annual cost is lowest i.e. Rs. 1,680.

Solution 8.

Chart Showing Optimal Replacement Period

Probability 0.3; 0.7

Individual replacement: Average life of bulb = 1 × 0.3 + 2 × 0.7 = 1.7

Weekly replacement = $\frac{100}{1.7} = 59$

Group replacement: 100 × 0.5 = 50

Week	Items to be replaced	Weekly cost	Cumulative cost	total cost	Avg. weekly cost
1	$100 \times 0.3 = 30$	30	30	80	80
2	$100 \times 0.7 + 30 \times 0.3 = 79$	79	109	159	79.50

It should be replaced by the end of second week. It cannot be replaced every third week as the life of the bulb is only 2 weeks.

Solution: 9 Replacement cost on individual basis $\frac{100 \times 10 = Rs.1{,}000}{5}$ = Rs. 200 per week. Replacement cost on group basis 3(100 × 0.3) + 3(100 × 0.1) + 3(100 × 0.1) + 3(100 × 0.2) + 3(100 × 0.3) = 300/5 = Rs.60/-

4.4 Change of Technology and its Implication

Technology is a resource of profound importance not only in production but also to profitability and growth of the entire business organisation. Technology drives productivity and also drives change in this world. Technological change is a major factor in gaining competitive advantage. The development and Innovative use of technology can provide a firm a distinctive competence. Competitive advantage can be achieved not just from creating new technology but also by applying and integrating existing technologies.

Technology is a significant ingredient in virtually all production and operations management decisions. Advances in computer technologies (both hardware and software) automation, robotics, lasers, and information and communication technologies have had broad-reaching impact across all industries. To stay competitive, manufacturing and service organisations must adopt new technologies.

Firms that have used technology as a competitive weapon have effectively integrated their technology strategy and business strategy. As these firms invent and develop new technologies, they offer new products and services.

Technology is defined to be know-how, physical things and procedures used to produce products and services. Know-how means knowledge and judgement of how, when and why to employ equipments, processes and procedures. Knowledge includes craftsmanship and experience, physical things are equipments and tools, procedures are the rules and techniques for operating the equipment and performing the work.

Technologies require a support network to be implemented. A support network consists of physical, informational and organisational relationships that make a technology complete and allow it to function as intended.

Advanced technology refers to the application of the latest scientific or engineering discoveries to the design of production and operations processes.

Technology and technique do not mean the same. Technique is the totality of methods rationally arrived at and having absolute efficiency whereas technology is the organisation and application of knowledge for the achievement of practical purposes. Some of the examples of technology are manufacturing or production technology, design technology, computer technology, communication technology, nuclear technology, satellite; communication technology, space technology, missile technology, laser technology and the like.

Advances in technologies create new products and services and reshape processes. Technology takes many forms, beginning with ideas, knowledge, and experience and then utilising them to create new sad better ways of doing things. Technology provides distinctive competency and competitive advantage to a firm over others. The impact of technology is pervasive.

A vital factor in production organisations is whether the technology involves capital intensive operation (i.e., large investment in plant and machinery) or labour-intensive operations. Technology will affect: (i) the organisation of production, (ii) the capital investment in plant and equipments buildings etc., (iii) the scale (or volume) of production operations, (iv) the influence of labour relations in-production operations.

The management of production is vitally concerned with the technology of the production processes. It must organise according to the technology adopted and by the adoption of productive system which is either capital intensive or labour intensive. Also, it must design a highly sophisticated production control system for batch production, or a material management system for high capacity assembly line operations.

The organisation is not simply a technical or social system. It requires structuring and integrating human activities around various technologies. The technical system is determined by the task requirements and shaped by the specialisation of knowledge and skills required, the types of machinery and equipments involved, the information processing requirements and the layout of facilities.

Any change in the technical system affects the organisational elements. The impact of technology on the organisation-its goals, structure, psychological system and managerial system will be quite significant.

Technology can be classified as: (i) manual technology, (ii) mechanised technology (or mechanisation), (iii) Automated technology (or automation), (iv) current technology, (v) appropriate technology, (vi) state-of-the-art technology, (vii)advanced technology, (viii) obsolete technology (or out-dated technology), (ix) capital-intensive technology, (x) labour intensive technology, etc.

Manual technology is the use of muscular power to do work which was prevalent before industrial revolution. Mechanised technology or mechanisation uses machine power in place of muscle power and is the first step towards automation. Examples of mechnisation are power operated tools, tool changing devices, powered materials handling equipments such as conveyors, jib cranes for loading and unloading heavy jobs etc. Automated technology or automation is any form of equipment or machine which will carryout a preset program or sequence of operations and at the same time measure and correct its actual performance in relation to that program. Current technology is any technology currently used by a firm in its operations. Appropriate technology is the technology which meets the requirements of time, place and objectives of a firm at a particular point of time. Appropriateness is an inherent quality in technology. Depending on the social, political, economic and other conditions prevailing in a country at a particular point of time and also depending on the priorities of the country, a technology becomes appropriate even though it may not be an advanced technology or state-or-the-art technology. (For example, whether capital-intensive or labour-intensive technology is the appropriate technology to be adopted by a firm or industry or a country).

State-of-the-art technology is a modern technology which has been adopted by many developed countries in the world. This technology will enable the firm to produce state-of the art products using state-of-the art design. It is also known as proven technology. Advanced technology is the latest technology based on the latest scientific or engineering discoveries and used in the design and production processes. It is also known as new technology which is developed by a firm which is a technology leader in its field of operation. Examples of advanced technologies are space technology, missile technology, information technology, laser technology, bio-technology and so on.

Obsolete technology is an out-dated technology which has been replaced by a superior technology, thereby resulting in obsolescence of the old technology which has been replaced.

Capital-intensive technology involves huge investments in capital assets such as equipment and machinery, materials handling and storage systems, information handling (storage and retrieval) systems, communication systems and office automation equipments.

Labour-intensive technology does not involve investment in huge capital intensive systems but make use of abundant labour (manpower) available in the country. For example, in India, textile and mining Industries adopt labour-intensive technologies.

The Choice of Technology: The choice of technology depends on several factors, both internal and external to the organisation choosing the technology. The various internal factors are : (i) availability of funds for investment, (ii) product life cycle and technology-life cycle position, (iii) present plant capacity and technology adopted (i.e., current technology).

Technology can be quite capital intensive and require high investment in equipments, machines and processes. The question is whether the firm can afford to invest in a new technology which may be highly expensive. Also, the change to a new technology is not advisable when the product is in the saturation or decline stage in its life cycle. New technologies for processing may be best suited for developing and manufacturing new products. The new technology chosen should be capable of matching with the existing technology and plant capacity so that there will be a synergy effect on the plant capacity when a new technology is adopted.

The external factors involved in the choice of technology are: (i) Government polices and regulations, availability of resources such as raw materials, energy, skilled labour etc., required for using the new technology, (ii) market scenario (market demand, customer requirement of product quality etc.).

Technology Life-Cycle: Like a product has its life cycle, technology also has a life cycle. The various phases or stages in a technology life cycle are:

(i) Innovation in which stage a new technology (product or process technology) is developed, (ii) Syndication during which stage, the technology is demonstrated and slowly commercialised, (iii) Diffusion stage in which a new technology gradually replaces the current technology and (iv) Substitution stage in which the current technology becomes obsolete and is completely replaced by the new technology.

The recent development in the technology of product design comprises certain tools provided by the information sciences that contribute to better, cheaper and faster design of products. They are:

(i) Computer-aided design (CAD)

(ii) Computer-aided design and manufacture (CAD/CAM).

(i) Computer Aided Design (CAD): It is an electronic system using computers for designing new parts or products or modifying existing ones, replacing the traditional drafting work done by a draftsman on a drafting board. The CAD consists of a powerful desktop computer and graphics software that enables a designer to manipulate geometric shapes. The designer can create drawings and view them from any angle on a display monitor. CAD softwares have been developed for designing electronic circuits, printed-circuit-board design, designing and drafting three dimensional drawings and also for analysis of heat and stress in mechanical designs.

Advantages of CAD are:

(i) Allows designers to save time and money by shortening design and development cycle time, (ii) Eliminates prototype model building to prove the design, (iii) Allows designers to determine costs and test such variable as stress, tolerance, product variability, interchangeability and serviceability, (iv) Low cost of design even for a custom-built, low volume product,(v) Eliminates manual drafting completely,(vi) Makes review of numerous options in design possible before final commitments are made because of the speed and ease with which sophisticated designs can be manipulated, (vii) Faster development, better products and accurate flow of information to other departments and (viii) Product cost can be determined at the design stage itself.

Production technology

In addition to the developments in design technology, a number of advances are made in technology used to enhance production. Some these advancements in production technology are:

(i) Numerical control and Computer Numerical Control (NC and CNC), (ii) Automated process controls, (in) Vision systems (automated inspection systems), (iv) Robots, (v) Automated identification systems (AIS), (vi) Automated storage and retrieval system (ASRS), (vii) Automated guided vehicles (AGV), (viii) Automated Sow lines, (ix) Automated assembly systems, (x) Flexible manufacturing systems (FMS), (xi) Computer integrated manufacturing (CIM), (xii) Enterprise resource planning.

The above aspects of production technologies are discussed in detail in the following section.

(i) Numerical Control and Computer Numerical Control: Many machines such as lathe, milling, drilling and boring machines are now designed for electronic control called numerical control (NC). The numerically controlled (NC) machines have control systems which read instructions and translate them into machine operations. When these machines are programmed through their own minicomputers and have memories to store these programs, they are called computer numerical control (CNC) machines.

Advantages of N/C Machines: (i) Smaller machine setup time, (ii) Machine motions and tool changing are controlled by instructions on a control system, (iii) Increased productivity and higher quality, (iv) Suitable for low volume production.

Advantages of CNC Machines: (i) Instructions may be stored and handled more efficiently, ii) Micro computer system controls the machine settings and operations rather than human beings, (iii) Real time and off-line diagnostic possibilities may be built into the CNC system, (iv) Machining data and operator instructions may be displayed on the screen of computer.

Application of NC/CNC Machines : These machines are used to machine parts (i) with complex machining requirements, (ii) requiring high precision, (iii) in developmental stages where many changes may be needed, (iv) normally requiring extensive tooling, (v) requiring fast or slow machining speeds, (vi) made from expensive raw materials and (vii) required in small quantities of repetitive batches.

(ii) Automated Process Control: Automated process control makes use of information technology to monitor and control a physical process. It is also used to determine and control temperatures, pressures and quantities in petroleum refineries, cement plants, chemical plants, steel mills, nuclear reactors etc., process control systems operate in a number of ways : (a) Sensors collect data, (b) Analog devices read data periodically (say once a minute or once a second), (c) Measurements are translated into digital signals which are transmitted to a digital computer, (d) Computer programs read the digital data and analyse the same, (e) The resulting output may take numerical forms which include messages on computer consoles or printers, signal to motors to change valve settings, warning lights or sirens etc.

(iii) Vision Systems (Automated Inspection Systems): These are machines or equipments that have been integrated into the inspection of products for controlling quality. They combine video camera and computing technology to take physical dimensions of parts, compare the measurements to standards and determine whether the parts meet quality specifications. Vision systems are also used for visual inspection in food processing organisations. Automated inspection systems facilitate 100 percent inspection which will lead to improved product quality and reduced inspection costs.

(iv) Robots: Robotics or robotry is a fast developing field of technology in which human like machines perform production tasks. A robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools or specialised devices through variable programmed motions for the performance of a variety of tasks. Robots are machines which are flexible, have the ability to hold, more and grab items. They are controlled by micro computers which when programmed guide the machines through their predetermined operations.

Advantages:

(i) do not strike work, (ii) do not mind hot, dirty, dusty working conditions, (iii) can work at high speeds, (iv) will not sue if injured, (v) can work long hours without breaks, (vi) can be used for welding, painting, assembly work, loading, unloading, material handling and other repetitive, monotonous work.

(v) Automated Identification Systems (AIS): These use bar codes, radio frequencies, magnetic stripes, optical character recognition and machine vision to sense and input data into computers. These systems replace human beings to read data from products, documents, parts and containers and interpret the data. An example is the system used to identify and read the bar code on an item in the check-out counters at grocery stores. A scanner reads the identification number from the bar code on the item accesses a computer data base, and sends the price of the item to the cash register and updates the ; inventory data in the inventory system.

(vi) Automated Storage and Retrieval Systems (ASRS): Computer controlled warehouses use ASRS; which provide for the automatic placement and withdrawal of parts and products into and from designated storage places in the warehouse. Such systems are commonly used in distribution facilities of retailers.

(vii) Automated Guided Vehicles (AGVs): These are automated materials handling and delivery systems which can take the form of mono-rails, conveyors, driverless trains, pallet trucks and unit load carriers. AGVs are electronically guided and controlled vehicles used to move parts and equipments. AGVs usually follow either embedded guide wires or paint strips through operations until their destinations are reached.

(viii) Automated Flow Lines: An automated flow line includes several automated machines which are linked by automated transfer machines and handling machines. The raw material feeders automatically feed the individual machines and operations are carried out without human intervention. After an item is machined on one machine on the line, the partially completed item is automatically transferred to the next machine on the line in a predetermined sequence, until the job is completed. Major components such as automobile rear axle housings are produced using automated flow lines. These systems are also known as fixed automation or hard automation because the flow lines are designed to produce only one type of component or product. These systems are suitable for products with high and stable demand because of very high initial investment required and the difficulty of changing over to other products. But production systems which provide greater flexibility (For example, Flexible Manufacturing Systems) are more favoured than fixed automation.

(ix) Automated Assembly Systems: In this system automated assembly machines or equipments are linked together by automated materials handling equipments. Examples of automated assembly equipments are robotic welders or component insertion unit which are used to join one or more parts or components or assemblies. The partially assembled product is moved to the next assembly equipment automatically by the automated materials handling equipments and this process is repeated until the whole assembly is completed. Automated assembly systems require unique product design which is suitable to these systems unlike product designs suitable for manual assembly operations. Some of the principles that are applied while designing products for automated assembly are:

(i) The amount of assembly required must be reduced: For example, use of castings or plastic mouldings (single part) instead of making the part by assembling two or more sheet metal parts fastened together by bolts and nuts or by rivets.

(ii) The number of fasteners required must be reduced: Joining two or more parts by welding is preferred to joining by fasteners such as screws, rivets, bolts and nuts. Product designs should facilitate this.

(iii) Components must be designed to be automatically delivered and positioned: Hoppers, slotted chutes, vibratory bowls etc. are used to feed the part and orient them to deliver to the assembly equipment and position in the proper place for assembly to be done automatically. Product designs should facilitate this.

(iv) Products must be designed for layered assembly and vertical insertion of parts: Product design must facilitate build up of assembly from a base upward in layers and the components inserted vertically into the assembly.

(v) Parts must be designed such that they are self aligning: Design should facilitate aligning of parts as and when they are inserted into assemblies.

(vi) Products must be designed into major modules for production (modular design): Each module is assembled in an automated assembly system and them the modules are assembled into the final product.

(vii) Quality of components should be high: High quality components avoid jams in feeding and assembly mechanisms. The advantages of automated assembly units are low production cost per unit, high product quality and higher product flexibility.

(x) Flexible Manufacturing System (FMS): A flexible manufacturing system (FMS) is a configuration of a group of production machines (or workstations) connected by automated material handling and transferring machines and integrated by computer system which can give instructions to produce hundreds of different parts in whatever order specified.

An FMS is a type of flexible automation system which builds on the programmable automation of NC and CNC machines. Materials are automatically handled and loaded and unloaded for machining operations. Programs and tooling set up can be quickly changed and production can be quickly switched on from one job to another with no loss of change over- time.

Key components of an FMS are:

(i) Several computers controlled machining centres or workstations having CNC machines and robots for loading and unloading.

(ii) Computer controlled transport system (AGVs) for moving materials and parts from one machine to another and in and out of the system.

(iii) Computer controlled robots for loading and unloading stations.

(iv) An automated storing and retrieval system.

All the above subsystems of FMS are controlled by a central computer with the needed software. Raw materials are loaded on the AGVs which bring them to the work centres as per the sequence of operations unique to each part. The route is determined by the central computer. The robots lift the materials from the AGV and place on the workstation, where the required operations are carried out. After the completion of operations, the robots unload the job and place it on the AGV to move the job to the next workstation as per the sequence of operations.

The FMS is suitable for intermediate flow strategies with medium level of product varieties and volumes (40 to 2000 units per part). Also, FMS can produce low variety high volume products in the same way as fixed automation systems.

Advantages: (i) Improved capital utilisation, (ii) Lower direct labour cost, (iii) Reduced inventory, (iv) Consistent quality, (v) Improved productivity.

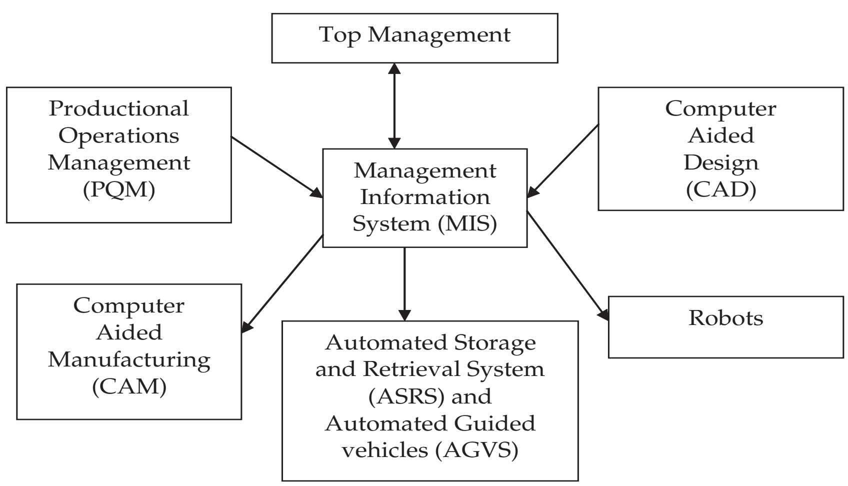
Disadvantage: (i) High initial capital investment, (ii) Limited ability to adopt to product changes, (iii) Substantial preplanning, tooling and fixture requirements, (iv) Standardisation of part designs needed to reduce number of tools required, (v) Requires long planning and development cycle to install FMS.

(xi) Computer Integrated Manufacturing (CIM): Computer Integrated Manufacturing is a system which acts as a bridge or umbrella to integrate product design and engineering, process planning and manufacturing using complex computer systems. It integrates CAD, CAM, FMS, inventory control, warehousing and shipping. A computer-aided drafting generates the necessary electronic instructions to run a direct numerically controlled (DNC) machine and any design change initiated at a CAD terminal can incorporate that change in the part produced on the shop floor within a few minutes. When this kind of capability is integrated with inventory control, warehousing and shipping as a part of a flexible manufacturing system, the entire system is called computer-integrated-manufacturing.

The CIM systems work as follows:

1. Top Management decides to make a product based on market opportunities, the company's strength and weaknesses and formulates its strategic plan based on competitive advantage.
2. Production/Operations Management implements production process, supplier coordination, material planning, scheduling operations, delivery schedules and cost controlling functions.
3. Computer-Aided-Design facilitates the design of the product, its quality analysis, planning the manufacturing process, designing tools and. fixtures and machine loading programs.
4. Computer-Aided-Manufacturing allows fabrication of raw materials into parts to be sent to the assembly lines.
5. Automated Storage and Retrieval System (ASRS) and automated guided vehicles (AGVs) facilitate storage/retrieval, movement of incoming materials and parts, work-in-process and finished products

Computer Integrated Manufacturing System



6. Robots assemble the subunits into final products, test them with automated equipments and put the finished products into containers for shipment.
7. Management Information System (MIS) integrates all the elements of the computer integrated systems among themselves and also with the top management of the organisation.

(xii) Enterprise Resource Planning (ERP) System: ERP systems comprise latest comprehensive software packages to automate a number of business processes. This software integrates most of the business functions in an organisation. ERP systems have automated manufacturing processes, organised account books, streamlined corporate departments such as human resources and facilitate business process re-engineering.

ERP systems need complex set of software programs and heavy investment to implement them. Several ERP software packages have been developed by leading software companies such as SAP, Oracle, J.D. Edwards, People Soft and Baan. The latest development in ERP system has been the integration of e-business capabilities.

E-business uses the internet to conduct or facilitate business transactions such as sales, purchasing, communication, inventory management, customer service, placing purchase orders and checking the status of purchase orders etc. ERP software packages were modified with additional features to facilitate e-business.

Automation Issues

Some of the issues to be deliberated in the use of automation are:

(i) Not all automation projects are successful.

(ii) Automation is not a substitute for poor management.

(iii) Some automation projects may not be worth-while based on economic analysis.

(iv) Some operations are not technically feasible to be automated.

(v) Small and start-up business may not be able to invest for automation projects.

Advantages and Disadvantages of Automation

Advantages: (i) Increased output and higher productivity, (ii) Improved and uniform quality, (iii) Reduced costs, (iv) Fewer accidents, (v) Better production control, (vi) Dangerous and unpleasant taste can be performed by robots.

Disadvantages: (i) Heavy capital investment, (ii) Displacement of labour, (iii) Loss of suggestions from employees, (iv) Design specifications for raw materials can not be relaxed, (v) Cost of shutdown of automated plant due to shortage of materials is quite high, (vi) Dehumanisation.

Factories of the Future

The features of factories of the future are:

1. Stress on high product quality.
2. Greater emphasis on flexibility.
3. Faster execution and delivery of customer orders.

4. Change in production economics - fixed costs will become variable and variable costs will change to fixed costs. Product will be designed using CAD/CAM which forms the basis for process planning also. CIM systems will be extensively used.

5. Organisational structure changes with line personnel becoming staff personnel and vice versa. The mainstream activities will be maintenance, quality assurance, product design and engineering managing technology change, software development etc.

6. The factories of future will be driven by computers used in CIM systems.

Objective Type Questions and Answer

Type: - Choosing of Correct Answers:

1 Application of technology or process to the raw material to add use value is known as:

(a) Product, (b) Production, (c) Application of technology, (d) Combination of technology and process.

Ans. (b)

2. Surface hardening is an example of:

(a) Production by application of machine tool, (b) Production by disintegration, (c) Production by Integration, (d) Production by Service.

Ans.(d)

3. In Production by disintegration the material undergoes:

(a) Change in economic value only, (b) Change in physical and chemical characteristics, (c) Change in technology only, (d) None of the above.

Ans.(b)

4. In Production by service, the product undergoes the changes in:

(a) Shape and size of the surface, (b) Shape of the surface only, (c) Size of the surface only,

(d) Chemical and Mechanical properties.

Ans.(d)

5. Use of any process or procedure designed to transform a set of input elements into a set of output elements is known as:

(a) Transformation process, (b) Transformation of input to output, (c) Production, (d) Technology change.

Ans.(c)

6. Conversion of inputs into outputs is known as:

(a) Application of technology, (b) Operations management, (c) Manufacturing products, (d) Product.

Ans.(b)

7. The desired objective of Production and Operations Management is:

(a) Use cheap machinery to produce, (b) To train unskilled workers to manufacture goods perfectly, (c) Optimal utilisation of available resources, (d) To earn good profits.

Ans.(c)

8. The scope of Production Planning and Control is:

(a) Limited to Production of products only, (b) Limited to production of services only, (c) Limited to production of services and products only, (d) Unlimited, can be applied to any type of activity.

Ans.(d)

9. Manufacturing system often produces:

   (a) Standardised products, (b) Standardised products in large volumes, (c) Substandard products in large volumes, (d) Products and services in limited volume.

   Ans.(a)

10. The difference between product system and project system is:

    (a) Project system the equipment and machinery are fixed where as in product system they are movable, (b) In Product system the machinery and equipment are fixed and in project system they are not fixed, (c) Project system produces only standardized products and product system produces only unstandardised products, (d) Products cannot be stocked whereas projects can be stocked.

    Ans.(b)

11. Most important benefit to the consumer from efficient production system is

    (a) He can save money, (b) He will have product of his choice easily available, (c) He gets increased use value in the product, (d) He can get the product on credit.

    Ans.(c)

12. Two important functions that are to be done by Production department are:

    (a) Forecasting, (b) Costing, (c) Scheduling and loading, (d) Inspecting.

    Ans.(c)

13. Fixing the flow lines of materials in production is known as:

    (a) Scheduling, (b) Loading, (c) Planning, (d) Routing.

    Ans.(d)

14. The act of releasing the production documents to the production department is known as:

    (a) Planning, (b) Routing, (c) Dispatching, (d) Releasing.

    Ans.(c)

15. The activity of specifying when to start the job and when to end the job is known as:

    (a) Plaining, (b) Scheduling, (c) Timing, (d) Follow-up.

    Ans.(b)

16. In an organization, generally the production management is a

    (a) Line function, (b) Staff function, (c) Line and Staff function, (d) None of the above.

    Ans.(a)

17. In an organisation the production planning and control department comes under:

    (a) Planning department, (b) Manufacturing department, (c) Personal department,

    (d) R & D department.

    Ans.(b)

18. In Job production system, we need:

    (a) More unskilled labours, (b) Skilled labours, (c) Semi-skilled labours, (d) Old people.

    Ans.(b)

19. In Continuous manufacturing system, we need:

    (a) General purpose machines and Skilled labours, (b) Special machine tools and highly skilled labours, (c) Semi automatic machines and unskilled labours, (d) General purpose machines and unskilled labours.

    Ans.(b)

20. Most suitable layout for Job production is:

    (a) Line layout, (b) Matrix layout, (c) Process layout, (d) Product layout.

    Ans.(c)

21. Most suitable layout for Continuous production is:

    (a) Line layout, (b) Process Layout, (c) Group technology, (d) Matrix layout.

    Ans.(a)

22. One of the product examples for Line layout is:

    (a) Repair workshop, (b) Welding shop, (c) Engineering College, (d) Cement.

    Ans.(d)

23. Number of product varieties that can be manufactured in Job production is:

    (a) Limited to one or two, (b) Large varieties of products, (c) One only, (d) None of the above.

    Ans.(b)

24. Number of product varieties that can be manufactured in Mass production is:

    (a) One only, (b) Two only, (c) Few varities in large volumes, (d) Large varities in small volumes.

    Ans.(c)

25. In general number of product varities that can be manufactured in Flow production is:

    (a) One only, (b) Ten to twenty varities, (c) Large varities, (d) Five only.

    Ans.(a)

26. Generally the size of the order for production in Job production is

    (a) Small, (b) Large, (c) Medium, (d) Very large.

    Ans.(a)

27. Generally in continuous production the production is carried out to:

    (a) Customer’s order, (b) Government orders only, (c) For stock and supply, (d) Few rich customers.

    Ans.(c)

28. Inventory cost per product in intermittent production is:

    (a) Higher, (b) Lowest, (c) Medium, (c) Abnormal.

    Ans.(a)

29. The material handling cost per unit of product in Continuous production is:

    (a) Highest compared to other systems, (b) Lower than other systems, (c) Negligible, (d) Cannot say.

    Ans.(b)

30. Routing and Scheduling becomes relatively complicated in

    (a) Job production, (b) Batch production, (c) Flow production, (d) Mass production.

    Ans.(b)

31. The starting point of Production cycle is:

    (a) Product design, (b) Production Planning, (c) Routing, (d) Market research.

    Ans.(d)

32. Variety reduction is generally known as:

    (a) Less varities, (b) Simplification, (c) Reduced varities, (d) None of the above.

    Ans.(b)

33. Preferred numbers are used to:

    (a) To determine the number of varities that are to be manufactured, (b) To the test the design of the product, (c) To ascertain the quality level of the product, (d) To evaluate the production cost.

    Ans.(a)

34. The act of assessing the future and make provisions for it is known as

    (a) Planning, (b) Forecasting, (c) Assessment, (d) Scheduling.

    Ans.(b)

35. For a marketing manager, the sales forecast is:

    (a) Estimate of the amount of unit sales or a specified future period, (b) Arranging the sales men to different segments of the market, (c) To distribute the goods through transport to satisfy the market demand, (d) To plan the sales methods.

    Ans.(a)

36. The time horizon selected for forecasting depends on:

    (a) The salability of the product, (b) The selling capacity of Salesman, (c) Purpose for which forecast is made, (d) Time required for production cycle.

    Ans. (c)

37. For production planning:

    (a) Shot term forecasting is useful, (b) Medium term forecasting is useful, (c) Long term forecasting is useful, (d) Forecasting is not useful.

    Ans.(a)

38.. In general, medium range forecasting period will be approximately:

    (a) 5 to 10 Years, (b) 2 to 3 days, (c) 3 to 6 months, (d) 10 to 20 years.

    Ans.(c)

39. The range of Long range forecasting period may be approximately:

    (a) 1 to 2 weeks, (b) 2 to 3 months, (c) 1 year, (d) above 5 years.

    Ans.(d)

40. To plan for future man power requirement:

    (a) Short term forecasting is used, (b) Long range forecasting is used, (c) Medium range forecasting is used, (d) There is no need to use forecasting, as future is uncertain.

    Ans.(b)

41. Long range forecasting is useful in:

    (a) Plan for Research and Development, (b) To Schedule jobs in Job production, (c) In purchasing the material to meet the present production demand, (d) To assess manpower required in the coming month.

    Ans.(a)

42. Medium range forecasting is useful in:

    (a) To assess the loading capacity of the machine, (b) To purchase a materials for next month, (c) To plan for-capacity adjustments, (d) To decide whether to receive production orders or not.

    Ans.(c)

43. To decide work load for men and machines:

    (a) Medium range forecasting is used, (b) Short term forecasting is used, (c) Long range forecasting is used, (d) A combination of long range and medium range forecasting is used.

    Ans.(b)

44. Important factor in forecasting production is:

    (a) Environmental changes, (b) Available capacity of machines, (c) Disposable income of the consumer, (d) Changes in the preference of the consumer.

    Ans.(b)

45. Technological development is an:

    (a) Upward trend, (b) Downward trend, (c) Seasonal trend, (d) Erratic trend.

    Ans.(a)

46. A method in which a trend line drawn in such a way that the sum of the squares of deviations of the actual points above and below the trend line is at the minimum is known as:

    (a) Squared trend method, (b) Equal square method, (c) Adjusted square method, (d) Least Square method.

    Ans.(d)

47. One of the advantages of Method of Least square is:

    (a) It is a very easy method, (b) It does not use mathematics, (c) Trend values of all years of the series may be obtained, (d) None of the above.

    Ans.(c)

48. Line of Best fit is another name given to:

    (a) Method of Least Squares, (b) Moving average method, (c) Semi average method, (d) Trend line method.

    Ans.(a)

49. One of the important basic objectives of Inventory management is:

    (a) To calculate EOQ for all materials in the organisation, (b) To go in person to the market and purchase the materials, (c) To employ the available capital efficiently so as to yield maximum results, (d) Once materials are issued to the departments, personally check how they are used.

    Ans.(c)

50. The best way of improving the productivity of capital is:

    (a) Purchase automatic machines, (b) Effective Labour control, (c) To use good financial management, (d) Productivity of capital is to be increased through effective materials management.

    Ans.(d)

51. MRP stands for:

    (a) Material Requirement Planning, (b) Material Reordering Planning, (c) Material Requisition Procedure, (d) Material Recording Procedure.

    Ans.(a)

52. JIT stands for:

    (a) Just in time purchase, (b) Just in time production, (c) Just in time use of materials, (d) Just in time order the material.

    Ans.(b)

53. The cycle time, selected in balancing a line must be:

    (a) Must be greater than the smallest time element given in the problem, (b) Must be less than the highest time element given in the problem, (c) Must be slightly greater than the highest time element given in the problem, (d) Left to the choice of the problem solver.

    Ans.(c)

54. The lead-time is the time:

(a) To placeholders for materials, (b) Time of receiving materials, (c) Time between receipt of material and using materials, (d) Time between placing the order and receiving the materials.

Ans.(d)

55. Production planning deals with:

(a) What production facilities is required and how these facilities should be laid out in space available, (b) What to produce and when to produce and where to sell, (c) What should be the demand for the product in future? (d) What is the life of the product?

Ans.(a)

56. The first stage in production planning is:

(a) Process Planning, (b) Factory Planning, (c) Operation Planning, (d) Layout planning.

Ans.(b)

57. In Process Planning we plan:

(a) Different machines required, (b) Different operations required, (c) We plan the flow of material in each department, (d) We design the product.

Ans.(c)

58. In Operation Planning:

(a) The planner plans each operation to be done at work centers and the sequence of operations, (b) Decide the tools to be used to perform the operations, (c) Decide the machine to be used to perform the operation, (d) Decide the materials to be used to produce the product.

Ans.(a)

59. Before thinking of routing, the production planner has to:

(a) Decide the optimal allocation of available resources, (b) To decide what type of labour to be used, (c) To decide how much of material is required, (d) To count how many orders he has on his hand.

Ans.(a)

60. The quantities for which the planner has to prepare production plan are known as:

(a) Optimal quantity of products, (b) Material planning, (c) Quantity planning, (d) Planning quantity standards.

Ans.(d)

61. The document, which is used to show planning quantity standards and production plan, is known as:

(a) Planning specifications, (b) Route sheet, (c) Bill of materials, (d) Operation sheet.

Ans.(a)

62. One of the seven routing decisions is:

    (a) Where to purchase the material?, (b) How to purchase material?, (c) When to purchase the material? (d) To make the product or buy the product?

    Ans.(d)

63. In route sheet or operation layout, one has to show:

    (a) A list of Materials to be used, (b) A list of machine tools to be used, (c) Every work center and the operation to be done at that work center, (d) The cost of product.

    Ans.(c)

64. The cycle time in selected in balancing a line must be:

    (a) Must be greater than the smallest time element given in the problem, (b) Must be less than the highest time element given in the problem, (c) Must be slightly greater than the highest time element given in the problem, (d) Left to the choice of the problem solver.

    Ans.(c)

65. In solving a problem on LOB, the number of workstations required is given by:

    (a) Cycle time/Total time, (b) Cycle time/Element time, (c) Total time/Element time, (d) Total time/ Cycle time.

    Ans.(d)

66. (Total station time/Cycle time × Number of work stations) × 100 is know as:

    (a) Line Efficiency, (b) Line smoothness, (c) Balance delay of line, (d) Station efficiency.

    Ans.(a)

67. Final stage of production planning, where production activities are coordinated and projected on a time scale is known as:

    (a) Scheduling, (b) Loading, (c) Expediting, (d) Routing.

    Ans.(a)

68. Scheduling shows:

    (a) Total cost of production, (b) Total material cost, (c) Which resource should do which job and when, (d)The flow line of materials.

    Ans.(c)

69. Scheduling deals with:

    (a) Number of jobs to be done on a machine, (b) Number of machine tools used to do a job, (c) Different materials used in the product, (d) Fixing up starting and finishing times of each operation in doing a job.

    Ans.(d)

70. The study of relationship between the load on hand and capacity of the work centers is known as:

(a) Scheduling, (b) Loading, (c) Routing, (d) Controlling.

Ans.(b)

71. One of the aims of loading is:

(a) To finish the job as early as possible, (b) To minimise the material utilisation, (c) To improve the quality of product, (d) To keep operator idle time, material waiting time and ancillary machine time at minimum.

Ans.(d)

72. One of the principles of Scheduling is:

(a) Principle of optimal product design, (b) Principle of selection of best material, (c) Principle of optimal operation sequence, (d) Principle of optimal cost.

Ans.(c)

73. The method used in scheduling a project is:

(a) A schedule of breakdown of orders, (b) Outline Master Programme, (c) PERT & CPM, (d) Schedule for large and integrated work.

Ans.(c)

74. Production planning in the intermediate range of time is termed as:

(a) Production planning, (b) Long range production planning, (c) Scheduling, (d) Aggregate planning.

Ans.(d)

75. One of the requirements of Aggregate Planning is:

(a) Both output and sales should be expressed in a logical overall unit of measuring, (b) Appropriate time period, (c) List of all resources available, (d) List of operations required.

Ans.(a)

76. In aggregate planning, one of the methods in modification of demand is:

(a) Differential Pricing, (b) Lay off of employees, (c) Over time working, (d) Sub contracting.

Ans.(a)

77. In aggregate planning one of the methods used to modification of supply is:

(a) Advertising and sales promotion, (b) Development of complimentary products, (c) Backlogging, (d) Hiring and lay off of employees depending on the situation.

Ans.(d)

78. The first stage of Production control is:

(a) Dispatching, (b) Scheduling, (c) Routing, (d) Triggering of production operations and observing the progress and record the deviation.

Ans.(d)

79. The act of releasing the production documents to production department is known as: (a) Routing, (b) Scheduling, (c) Expediting, (d) Dispatching.

    Ans.(d)

80. One of the important production documents is:

    (a) Design sheet of the product, (b) List of materials, (c) Route card, (d) Control chart.

    Ans.(c)

81. One of the important charts used in Programme control is:

    (a) Material chart, (b) Gantt chart, (c) Route chart, (d) Inspection chart.

    Ans.(b)

82. The way in which we can assess the efficiency of the production plant is by:

    (a) Efficient dispatching, (b) By manufacturing a good product, (c) By comparing the actual performance with targets specified in the specified programme, (d) By efficient production planning.

    Ans.(c)

83. Production control concerned with:

    (a) Passive assessment of plant performance, (b) Strict control on labours, (c) Good materials management, (d) Good product design.

    Ans.(a)

84. Dispatching is toughest in:

    (a) Job Production, (b) Mass production, (c) Batch production, (d) Flow production.

    Ans.(c)

85. One of the documents to be prepared in dispatching department is:

    (a) Time series for forecasting, (b) Cost sheets of products, (c) A shop order for each component, (d) None of the above.

    Ans.(c)

86. The type of dispatching function to be used depends much on the:

    (a) Type of product, (b) Type of production and on the size of the plant, (c) Type of materials used in production, (d) Type of management style.

    Ans.(b)

87. One of the aims of dispatching is:

    (a) To look after the welfare of the labour, (b) To test the quality of the product, (c) To dispatch the products to different places, (d) Principle of completion of job by due date.

    Ans.(d)

88. When work centers are used in optimal sequence to do the jobs, we can:

(a) Minimise the set up time, (b) Minimse operation time, (c) Minimise the break down of machines, (d) Minimise the utility of facility.

Ans.(a)

89. Route card and technological route card are:

(a) Different type of documents, (b) Same type of documents, (c) Route card shows route and technological route card shows the technology used, (d) One is prepared by production manager, dispatcher prepares other.

Ans.(b)

90. The card, which is prepared by dispatching department to book the labour involved in each operations:

(a) Labour card, (b) Wage card, (c) Credit card, (d) Job card

Ans.(d)

91. The card, which shows, the number of rejected products from total quantity produced is:

(a) Quality control card, (b) Inspection card, (c) Rejection card, (d) Job card.

Ans.(b)

92. The act of going round the production shop to note down the progress of work and feedback the information is known as:

(a) Follow up, (b) Dispatching, (c) Routing, (d) Trip card.

Ans.(a)

93. One of the activities of expediting is:

(a) To file the orders in sequence, (b) To decide the sequence of operation, (c) To record the actual production against the scheduled production, (d) To examine the tools used in production.

Ans.(c)

94. The class timetable is a good example of:

(a) Route sheet, (b) Follow-up chart, (c) Dispatcher's chart, (d) Gantt chart.

Ans.(d)

95. 'Z' chart is a chart used in:

(a) Programme control, (b) Job control, (c) Cost control,(d) Quality control.

Ans.(a)

96. Z-chart can be used to show:

(a) Process used in production, (b) Quality level of the product, (c) Both the plan and the performance, and deviation from the plan, (d) To show cost structure of the product.

Ans.(c)

97. Computers are used in Production control in this area:

(a) Follow-up activity, (b) To control labour, (c) To disseminate information, (d) Loading, Scheduling and Assignment works.

Ans.(d)

OTHER TYPES

Question

Match the Activity/Operation in Column I with the machine/equipment in Column II.

	I		II
A.	Feeding coal continuously into the furnace in an Electric Power Station.	i.	Electromagnet
B.	Handling crates on Pallets within a factory.	ii.	Electric Arc Furnace
C.	Moving a heavy load above the machine on the shop-floor in a workshop.	iii.	Gravity Chute
D.	Transporting fertiliser packed in bags to a railway wagon/truck on the ground below.	iv.	Drilling Machine
E.	Making a small deep hole in block of metal.	v.	Plaining Machine
F.	Machining a large flat surface on metal.	vi.	E.O.T. Crane
G.	Melting steel for making castings.	vii.	Fork-lift Truck
H.	Picking up bits of iron and steel in a scrap yard.	viii	Belt Conveyor

Answer

A: viii. Belt Conveyor

B: vii. Fork-lift Truck

C: vi. E.O.T. Crane

D: iii. Gravity Chute

E: iv. Drilling Machine

F: v. Planning Machine

G: ii. Electric Arc Furnace

H: i. Electromagnet

Question

Match the product in Column I with the production centre/equipment/plant in Column II.

I	II
A. Furniture	i. Assembly line
B. Hydro-electricity	ii. Refinery
C. Television set	iii. Foundry
D. Cement	iv. Carpentry
E. Rails	v. Smithy
F. Aviation Fuel	vi. Turbo-Alternator
G. Tools	vii. Blast Furnace
H. Castings	viii. Rotary Kiln
1. Forgings	ix. Rolling Mills
J. Pig Iron	x. Machine shop

Answer

Matching:

I	II
A. Furniture	iv. Carpentry
B. Hydro-electricity	vi. Turbo-Alternator
C. Television Set	i. Assembly Line
D. Cement	viii. Rotary Kiln
E. Rails	ix. Rolling Mills
F. Aviation Fuel	ii. Refinery
G. Tools	x. Machine Shop
H. Castings	iii. Foundry
I. Forgings	v. Smithy
J. Pig Iron	vii. Blast Furnace

Question

Match the terms shown under 'X' with their relevant terms; shown under 'Y'.

X	Y
a. Ranking Method	1. Method Study
b. Motion Economy	2. Plant Layout
c. Work Sampling	3. Job Evaluation
d. Normal Curve	4. Material Handling
e. Use of Templates	5. Inventory Control
f. Gravity Chute	6. Statistical Quality Control
g. Crashing	7. Network Analysis
h. Replacement	8. Value Analysis
i. Brainstorming	9. Work Measurement
j. Stock Level	10. Maintenance

Answer

Matching:

X	Y
a. Ranking Method	3. Job Evaluation
b. Motion Economy	1. Method Study
c. Work Sampling	9. Work Measurement
d. Normal Curve	6. Statistical Quality Control
e. Use of Templates	2. Plant Layout
f. Gravity Chute	4. Material Handling
g. Crashing	7. Net work Analysis
h. Replacement	10.Maintenance
i. Brainstorming	8. Value Analysis
j. Stock Level	5. Inventory Control

Question

Match the products in Column I with the production centers in Column II.

I	II
(A) Steam	(a) Blast Furnace
(B) Electricity	(b) Boiler
(C) Steel	(c) Generator
(D) Petrol	(d) Open Hearth Furnace
(E) Iron	(e) Refinery
(F) Cloth	(f) Assembly Line
(G) Car	(g) Smithy
(H) Castings	(h) Spinning Mill
(I) Cotton Yarn	(i) Foundry
(J) Forgings	(j) Power Loom

Answer

Matching:

I	II
(A) Steam	(b) Boiler
(B) Electricity	(c) Generator
(C) Steel	(d) Open Hearth Furnace
(D) Petrol	(e) Refinery
(E) Iron	(a) Blast Furnace
(F) Cloth	(j) Power Loom
(G) Car	(f) Assembly Line
(H) Castings	(i) Foundry
(I) Cotton Yarn	(h) Spinning Mill
(J) Forgings	(g) Smithy

Question

State whether the following statements are TRUE or FALSE.

(i) Method Study should precede Work Measurement.

(ii) Merit Rating is used to determine the cost of a product.

(iii) Production planning is an essential function in a factory.

(iv) Training boosts employee morale.

(v) A good Materials Handling system always consists of conveyors.

(vi) Increased productivity leads to cost reduction.

(vii) Project costs increase as the duration of the project increases.

(viii) When demand does not exist in the market, we should start Production Incentives.

(ix) A work stoppage generally reduces the cost of production.

(x) No handling is the best handling.

Answer

i. True ii. False iii. True iv. True v. False vi. True vii. True viii. False ix. False x. True.

Question

State whether the following statements are TRUE or FALSE.

(a) It is desirable to conduct work measurement after Method study.

(b) Job Evaluation is used to measure absolute job worth.

(c) Incentive scheme is introduced by Management with a view to reduce direct labour cost.

(d) The increase in productivity can be attributed to the application of Industrial Engineering/Techniques, particularly the work study.

(e) Operation process chart incorporates all five symbols.

(f) Multiple Activity chart deals with layout problems.

(g) Standard performance is the natural rate of working of an average operator when he works tinder proper supervision but without any financial motivation.

(h) Allowances for non-availability of materials power failure and breakdown of machines are provided for in the standard time for an operation/job.

(i) In carrying-out Job Evaluation studies, point system is the best method.

(j) It is justified to consider the effect of working condition both in Work Measurement and Job-Evaluation.

Answer

(a) True (b) False (c) False (d) True (e) True (f) False (g) False (h) False (i) True (j) True.

Question

State whether the following statements are TRUE or FALSE.

a. Adverse working condition would not be a factor in job evaluation where this is already compensated by suitable allowances in the Standard Time.

b. Standard Time for a Job should be more in India than in Europe because labour productivity here is low.

c. It is a proven fact that higher productivity invariably results in poorer quality of products.

d. There is a limit beyond which labour productivity cannot be improved.

e. Standard Man Hour is the only unit that can be used for output measurement in all types of factories.

f. Job enrichment means increased work load for the worker.

g. Methods improvement has unlimited scope.

h. Value Engineering aims at reducing work content of a product.

i. Primary objectives of an incentive scheme should be to link a part of the workers' earnings with productivity.

j. Job Evaluation establishes relative job worth only.

Answer

(a) False (b) False (c) False (d) True (e) False (f) False (g) True (h) False (i) True (j) True.

Question

State whether the following statements are TRUE or FALSE.

a. Increase in productivity leads to retrenchment of work force.

b. In view of rapid technological advancement we would not concentrate on labour productivity.

c. Piece wage system is a substitute for proper supervision.

d. Personnel Manager has nothing to do with productivity. It is the job of Technical Personnel.

e. Ranking is one of the Job Evaluation Techniques.

f. Results available from work sampling study is not 100% accurate.

g. Since breakdown of Plant and machineries is a random phenomenon, it is impossible to do any work measurement in Maintenance Area.

h. Job Evaluation does not help in performance Rating i. There is no difference between Method study and Value Engineering.

i. Two-handed process chart is the most suitable Recording Technique in Electronics Assembly Industry.

Answer

(a) False (b) False (c) False (d) False (e) True (f) True (g) False (h) False (i) False.

Question

Mention the name of the metal working process involved in carrying out the following operations and also states the machine/equipment on which this is carried out.

(i) Reducing the diameter of a cylindrical object.

(ii) Making a cylindrical hole of an object.

(iii) Very line finishing of the inside diameter of a cylinder liner,

(iv) Cutting a 'V' groove on a flat surface.

(v) Reducing the thickness of one side of a metal cube.

(vi) Joining two metallic objects.

Answer

S. No.	Metal working process	Machine/Equipment
i.	Turning	Centre Lathe
ii.	Drilling	Pillar Drill or Radial Drill
iii.	Honing	Honing Machine
iv.	Shaping	Shaping Machine
v.	Milling	Milling Machine
vi	Welding	Welder (Gas or Electric)

Note:- Alternative to vi. it can be done by Riveting also. In such case Pneumatic/or steam riveter can be used.

Question

Select general purpose machine tools to produce the following:

(i) 'V' groove in a Vee-block

(ii) Helicel groove on shaft

(iii) Thread in a nut

(iv) Hole in a block

(v) Portion of shaft to be supported in a bearing sleeve

(vi) A flat surface on a large foundation block

(vii) A flat face at the end of a shaft

(viii) Teeth on a gear wheel.

Answer

S. No.	Machine
i.	Shaping Machine
ii.	Milling Machine
iii.	Lathe
iv.	Drilling Machine
v.	Grinding Machine
vi.	Planning machine
vii.	Lathe
viii.	Milling machine or Hobbing machine

Question

Mention 8 different techniques which are used for improving productivity in industry.

Answer

1. Method study.
2. Motion and time study.
3. Ergonomics (or Human Engineering).
4. Network Analysis-PERT/CPM etc. for planning.
5. Value Analysis.
6. Statistical Quality Control (SQC).
7. Operation Research-Linear Programming etc.
8. Inventory control.
9. Budgetary control.
10. Management by objectives (MBO).

Question

What recording technique will you use for the following production situation ?

i. To have bird's view of a chemical process.

ii. To develop work bench layout .

iii. To reduce movement of materials.

iv. To study one operator running one machine.

v. To reduce ineffective body movements.

Answer

S. No.	Recording Technique
i.	Outline Process Chart
ii.	Travel chart
iii.	Flow Diagram
iv.	Machine Data Card
v.	First Motion study Second Man-Machine chart

Question

Give your views on the following statements:

a. Incentives are substitute for lower wages.

b. Mechanisation and Automation lower employee morale.

c. Total productivity of a given situation cannot be measured in absolute terms.

d. Method study should precede work measurement.

Answer

a. No. Incentives are in addition to wages and are meant for increasing production and improving productivity.

b. No. They will simplify job and as such morale will improve.

c. No. In such case output and input can be converted into monetary terms and productivity measured.

d. Yes.

Question

Give your views on the following statements:

a. Incentives are substitute for lower wages.

b. Job Enlargement (and not the division of labour) is the key to higher productivity.

c. Method study should precede work measurement.

d. A standard Job Evaluation Manual can be applied to any group of jobs for the purpose of Job Evaluation.

Answer

a. No Incentives are in addition to wages and are meant for increasing production and improving productivity.

b. Yes.

c. Yes. Methods should be standardised and then work measurement (i.e. Time study) is to be undertaken.

d. No.

Question

List six resources on which quality depends.

Answer

(1) Shape (2) Dimension (3) Composition (4) Strength (5) Workmanship (6) Finish.

Question

Answer the following queries with 'Yes' or 'No'.

(i) Would Zero-based budgeting require greater involvement of operating departments?

(ii) Is electric power required to run a gravity roller conveyor?

(iii) Does the time over-run in a project affect its cost?

(iv) Do Job-Evaluation and Value Analysis concern the same technique?

(v) Does the work 'tolerance' in engineering practice refer to the ability of workmen to endure boredom?

Answer

(i) Yes (ii) No (iii) Yes (iv) No (v) No.

Question

Match the material handling equipment in column I with the application in column II.

I	II
A. Fork lift Truck	(a) move bulk material continuously
B. Jib crane	(b) move heavy loads over rectangular area
C. Belt Conveyor	(c) move heavy loads within a circular area
D. Electric Overhead Travelling crane	(d) move loads down
E. Gravity Chute	(e) move palletised unit loads

Answer

Matching	Particular
A — e	Fork lift Trucks move Palletised unit loads.
B — a	Jib cranes move bulk material continuously.
C — c	Belt Conveyors move heavy loads within a circula area.
D — b	Electric Overhead Travelling (EOT) cranes move heavy loads over rectangular area.
E — d	Gravity Chutes move loads down.

Question

Indicate whether the following statements are TRUE or FALSE:

(i) A bill of materials is prepared by the Sales Department in an organisation.

(ii) Progressing ensures that production takes place according to plan.

(iii) Most castings are made in green sand mouldings.

(iv) Only railway workshops use engine lathes.

(v) Drawings, where applicable, are the best: means of expressing product specification.

(vi) Work content of a job is established by Job Evaluation.

(vii) Industrial Engineering is not a line function.

(viii) Scanlon plan is a system of production, planning and control.

Answer

(i)	False.	(v)	True.
(ii)	True.	(vi)	False.
(iii)	True.	(vii)	True.
(iv)	False.	(viii)	False.

Question

Answer the following Queries:

(i) Do standard Times allow for relaxation of the Operators?

(ii) Is a lift same as an elevator?

(iii) Is the use of metric system of weights and measures compulsory in India?

(iv) Can the shaping machine be considered a versatile machine tool?

(v) Is payment of Gratuity to Workmen compulsory in India now?

(vi) Does the Factories Act in India allow the employment of women in all industries?

(vii) Is Break-even analysis a management tool?

(viii) Is Activity Sampling a technique of Job Evaluation?

Answer

(i)	Yes	(v)	Yes
(ii)	Yes	(vi)	No
(iii)	Yes	(vii)	Yes
(iv)	No	(viii)	No

Question

Given below are two lists—list 'A' containing 11 abbreviations and list 'B' containing various functional areas associated with production management. Expand the abbreviations and match them with the corresponding functional areas.

List 'A'	List 'B'
LP	Capacity planning
PERT	Quality control
MTM	Project funding
VA	Project viability checking
CRAFT	Inventory management
SRAC	Product design
MRP	Cost control
CBA	Product mix determination
CAD	Plant layout
IFCI	Project planning
AOQ	Work measurement

Answer

List 'A'	Expansion	Matching with List 'B'
LP	Linear Programming	Product mix determination
PERT	Programme Evaluation and Review Technique	Project planning
MTM	Methods Time measurement	Work measurement
VA	Value Analysis	Cost control
CRAFT	Computerised Relative Allocation of Facilities Technique	Plant layout
SRAC	Short Run Average Cost	Capacity planning
MRP	Materials Requirement	Inventory management
CBA	Cost Benefit Analysis	Project viability checking
CAD	Computer Aided Design	Product design
IFCI	Industrial Finance Corporation of India	Project funding
AOQ	Average outgoing Quality	Quality control

Question

Match the terms shown under 'X' with the relevant terms shown under 'Y'.

	X	Y
(i)	Foundry	(a) Gearbox
(ii)	Machine shop	(b) Value Analysis
(iii)	Brainstorming	(c) Electrode
(iv)	Automobile	(d) Lathe
(v)	Forge Shop	(e) Cupola
(vi)	Welding	(f) Power Hammer
(vii)	Heat Treatment	(g) Rubber
(viii)	Tyre Plant	(h) Hardening
(ix)	Assembly line	(i) Go-No Go gauge
(x)	Inspection1	(j) Conveyor

Answer

X	Y
(i) Foundry	(e) Cupola
(ii) Machine Shop	(d) Lathe
(iii) Brainstorming	(b) Value Analysis
(iv) Automobile	(a) Gearbox
(v) Forge Shop	(f) Power Hammer
(vi) Welding	(c) Electrode
(vii) Heat Treatment	(h) Hardening
(viii) Tyre Plant	(g) Rubber
(ix) Assembly Line	(j) Conveyor
(x) Inspection	(i) Go-No Go Gauge

Question

Match the terms in column I with the relevant terms in column II.

I	II
(a) UCL	(i) Work Measurement
(b) MTM	(ii) Project Management
(c) CPM	(iii) Public Sector
(d) LP	(iv) Quality Control
(e) BIS	(v) Optimisation
(f) FIFO	(vi) Standardisation
(g) MTBF	(vii) Reliability
(h) BPE	(viii) Inventory Management
(i) WIP	(ix) Cost Accounting
(j) VOH	(x) Production Control

Answer

(a)	UCL	(iv)	Quality Control
(b)	MTM	(i)	Work Measurement
(c)	CPM	(ii)	Project Management
(d)	LP	(v)	Optimisation
(e)	BIS	(vi)	Standardisation
(f)	FIFO	(viii)	Inventory Management
(g)	MTBF	(vii)	Reliability
(h)	BPE	(iii)	Public Sector
(i)	WIP	(x)	Production Control
(j)	VOH	(ix)	Cost Accounting

Question

Given below are two lists-List A containing abbreviations and List B containing various functional areas associated with production management. Expand the abbreviations and match them with the corresponding functional areas.

List A	List B
LP	Product design
PERT	Quality control
MTM	Project funding
VA	Project viability checking
CRAFT	Inventory management
MRP	Cost control
CBA	Product-mix determination
CAD	Plant layout
IFCI	Project Planning
AOQ	Work measurement

Answer

(i) LP — Linear Programming — Product mix determination.

(ii) PERT — Programme Evaluation and Review Technique — Project planning.

(iii) MTM — Methods Time Measurement — Work measurement.

(iv) VA — Value Analysis — Cost control.

(v) CRAFT — Computerised Relative Allocation of Facilities Techniques — Plant layout.

(vi) MRP — Materials Requirement Planning — Inventory management.

(vii) CBA — Cost Benefits Analysis — Project Viability checking.

(viii) CAD — Computer Aided (or Assisted) Design — Product Design.

(xi) IFCI — Industrial Finance Corporation of India — Project funding.

(x) AOQ — Average outgoing Quality — Quality control.

Question

Match the terms in column 1 with the relevant terms in column II.

I	II
(a) ISO	(i) Work Study
(b) PBT	(ii) Inventory Control
(c) CNC	(iii) Standardisation
(d) JIT	(iv) Profitability
(e) PMTS	(v) Machine Tool
(f) ESI	(vi) Computer Programme
(g) COBOL	(vii) Public Sector
(h) ITI	(viii) Welfare
(i) CPM	(ix) Employee Relations
(j) IR	(x) Project Management

Answer

(a) ISO	(iii) Standardisation
(b) PBT	(iv) Profitability
(c) CNC	(v) Machine Tool
(d) JIT	(ii) Inventory Control
(e) PMTS	(i) Work Study
(f) ESI	(viii) Welfare
(g) COBOL	(vi) Computer Programme
(h) ITI	(vii) Public Sector
(i) CPM	(x) Project Management
(j) IR	(ix) Employee Relations

Question

Expand the following 10 abbreviations indicated in column X and then match the same with the most appropriate one indicated in Column Y on the right-hand side.

X	Y
SPT	Standardisation
ICICI	Labour related standards
ABC	Scheduling
ISO	Tax based on cost of additional processing
PPC	Venture Capital
LCL	Machines used for producing a class of products
SPM	Manufacturing planning and monitoring
VAT	Marketing strategy
USP	Statistical Quality Control
ILO	Classification based on annual usage value

Answer

SPT	Shortest Processing Time — Scheduling
ICICI	Industrial Credit and Investment Corporation of India — Venture Capital
ABC	Always Better Control — Classification based on annual usage value
ISO	International Standards Organisation — Standardisation
PPC	Production Planning and Control — Manufacturing planning and monitoring
LCL	Lower Control Limit — Statistical Quality Control
SPM	Special Purpose Machine Tools — Machines for producing a class of products
VAT	Value Added Tax — Tax based on additional Cost of processing
USP	Unique Selling Proposition — Marketing strategy
ILO	International Labour Organization — Labour related standards

Question

Choose the word or phrase which would be appropriate to fill up the blanks in each statement:

(i) Statistical analysis is used to determine the optimum policy of ________maintenance.

(ii) Watch and ward personnel are responsible for ________aspects in a factory.

(iii) General purpose machine are less prone to___________.

(iv) The pattern shop in a factory should ideally be near the____________.

(v) Factor Comparison is a method of_____________.

(vi) Taylor originated the idea of__________relationships in an organisation.

(vii) _____________cannot be delegated.

(viii) Ergonomics is another name for_________________.

(ix) _______________layout is used for mass production.

(x) Gantt chart is used for____________ control.

Answer

(i) preventive

(ii) security

(iii) obsolescence

(iv) foundry

(v) job evaluation

(vi) functional

(vii) responsibility

(viii)human engineering

(ix) product

(x) production

Question

Match each of the words in column I with the most appropriate ones from column II:

I	II
(A) Foundry	(a) Gauge
(B) Smithy	(b) Conveyor
(C) Machine shop	(c) Mould
(D) Welding	(d) Forge
(E) Heat treatment	(e) Lathe
(F) Assembly line	(f) Microscope
(G) Inspection	(g) Stacker
(H) Laboratory	(h) Furnace
(I) Design office	(i) Electrode
(J) Warehouse	(j) Pantograph

Answer

I	II
(A) Foundry	(c) Mould
(B) Smithy	(d) Forge
(C) Machine shop	(e) Lathe
(D) Welding	(i) Electrode
(E) Heat treatment.	(h) Furnace
(F) Assembly line	(b) Conveyor
(G) Inspection	(a) Gauge
(H) Laboratory	(1) Microscope
(I) Design office	(j) Pantograph
(J) Warehouse	(g) Stacker

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Part - II
Information System

STUDY NOTE - 1

Information System

1.1 Contribution of Information Technology in the Social life and Industrial fields

Information Technology has become the most dynamic area in human life today. In social life, from education, entertainment to economic development programme, everywhere information processing gives direction for plans and programmes. The world has become a global village with the power of communication technology. Physical location is no barrier for communication. Power of computers and communication technology has redefined information technology and has brought a new dimension in its use. A business can not run with information flow. The visualization of importance of timely information has created new atmosphere for intensive research and development programme for evolving new techniques and tools in the field of information technology. This is why we call that the present age is the age of Information.

We see the marvelous power of computer and it has grabbed all areas of modern life. Its speed, accuracy and storage facility have charmed everybody. The inherent aptitude of man for mathematics felt the need for a machine to calculate the arithmetical figures. With this urge man could develop a device which has brought a new taste of life. Innovations in the use information technology are examples of human brain power. No body can guess the end of it. A small list can only give an amazing dimension - use of robot to control production and quality in the factory, conference among people at different corners in the world through communication, remote control of space craft from Earth Station and so on. Nothing is left on earth which is untouched by IT today. Each and every activity of day–to-day life like to have a golden touch of it. Let us have the glimpses of its small range which are

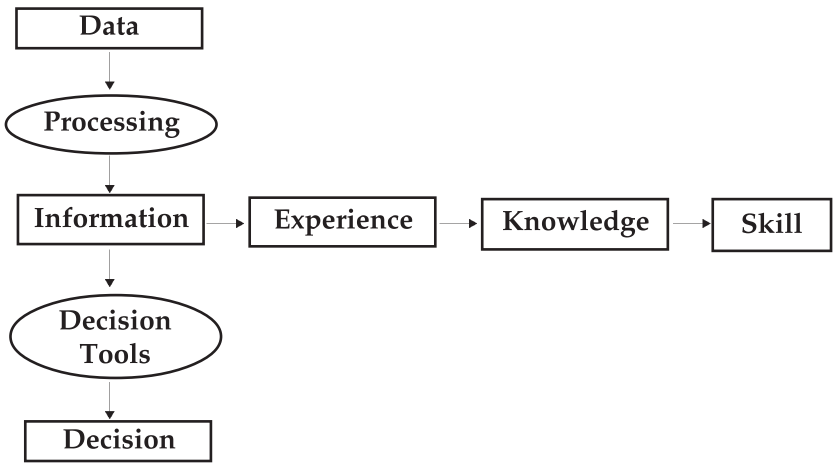
- Education and Training
- Medical science
- Engineering science
- Space research
- Research in bio-technology
- Entertainment etc.

Information is the backbone in a business organization. In today's competition, managing information is the most critical task for survival. Information Technology plays a crucial role in dissemination of information towards controlling business operation. The work of computer has been extended from data processing to on-line Management Information system, Sales information to E-commerce, Decision making to Expert system. The challenges ahead are the fields like:

- Process Control in production management
- Flow of information through internet
- Integration of functional systems with network
- E-Commerce in business
- Knowledge based Expert System in decision making etc

1.2 Information

Information is nothing but refined data. Data before processing is said to be raw data. Raw data are collected, screened and processed to make it organized for effective use. Data after processing become linked with other data and carry meanings and, strictly speaking, to be termed as information. Information is data that has been processed into a form that is meaningful to the user in effective interpretation and decision making. Information involves communication and reception of intelligence. Information consists of data, text, images, voice etc. The term data in normal sense includes all these.



Characteristics of useful Information:

The following are the characteristics of information. These characteristics determine the quality and usefulness of information :

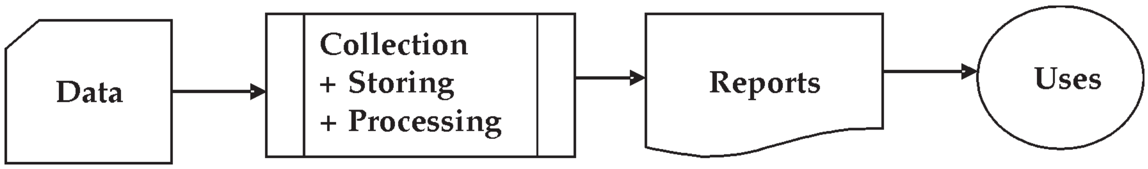
- ***Timeliness*** – This parameter is important to increase effectiveness in the use.
- ***Accuracy*** – The most important ingredient for quality of information.
- ***Comprehensive*** – Information should be integrated one with all other related issues to make it more meaningful.
- ***Relevance*** - The need for type of information differs from user to user. Relevant information filtered for a purpose ensures its effective and best use.
- ***Understandability*** - The information must be presented in a form that users can interpret the same for decision making.

1.3 Information System

An Information System is designed by an user according to the business operation involved and the need for his decision making. It is a vehicle which supplies necessary information for decision making. Before computer being used in an business environment, Information System also existed in some form to support management in decision making. To-day business environment has become very complex and highly competitive. If an organization has to survive, it has to plan and develop its own Information System. Of course, the size, structure and set up may vary depending upon the need of the organization, policy and capability. In today's business environment computer has become a must for an information system. The information system is to feed the management for control purpose. This is why Information System is generally called as Management Information System (MIS) or Computer Based Information System (CBIS).

Generally, am MIS uses Computer System and Communication technology to collect information from different operational points and disseminate them at different users for decision making. The activities in an Information System are :

- Collection, storing and processing data
- Generation of Information Reports
- Dissemination of Information to right users



An MIS provides timely information of right quality for better management decision making for developing business strategy. The advantages of CBIS are :

- Reduction in cost of record maintenance
- Improvement in the efficiency of human resources
- Regular flow of information at different levels of management
- Easy use of scientific tools and models for quality decision making
- Faster response to customers
- Better control over resources
- Faster access to records in case of dispute
- Effective use of manpower etc.

***Characteristics of an Information System* : -** The following are the general characteristics of an Information system :

i) ***Specific objective*** : The information system should have some specific objective. An Information System in highly scientific research centre will have an objective to accumulate data from different activities, display of some information instantly for controlling activities and so on. In a business environment, the objective will be sharing information from different functional areas and smooth flow of information for management decision making.

ii) ***Structured*** : An information system should have a definite structure with all modules of sub-systems. The structure depends on the sub-modules, their interactions and integration requirements, operational procedure to be followed and the solution sets. The structure of the information system refers to diagrammatic representation of the system showing sub-systems, their inter-relation and the procedure to be followed to fulfill the process requirements.

iii) ***Components*** : The sub-systems are the components. The sub-systems should be distinguishable among themselves but have well-defined relation among. For example, a Sales system may be sub-systems like Invoicing, Delivery monitoring, and Sales Proceeds Collection system. The inter-link between these systems must be well defined.

iv) ***Integrated*****:** An Information System should be designed in such a fashion that proper integration among sub-systems are taken care to establish correct linkage and generate meaningful information. An information in isolation may not be that meaningful but its usage is improved if it is integrated with information of other closely related issues. For example, Sales information of a region becomes more meaningful if other information like previous period sales, sales in other regions, sales of competitive products are also combined in the information set.

v) ***Life-Cycle*****:** An Information system will have its own life-cycle. The duration of life cycle varies from the system to system. An information system has the similar stages of life-cycle as seen in any other system. Every information system will have distinctly different phases - Initial, Growth, Maturity and Decline.

vi) ***Behaviour***: A system has its own set reaction and outcome depending on the environment. A well managed business information system behaves nicely with its users by satisfying them with correct and timely information. The design of the system plays a good role in setting its behaviour pattern.

vii) ***Self-regulatory***: An Information System which may have different sub-systems interacting with the each other in a desired fashion to be operative smoothly and in the process they regulate themselves. This is what is self-regulatory nature of the system. A payroll system involves three activities – first, maintaining attendance of employees, second, pay calculation and third pay disbursement. If the target date for pay disbursement is last date of a month, the second adjusts its start time accordingly and the first one is also regulated in such a fashion that it can provide input to the second in time.

1.4 Open and Closed System

1.4.1 Open System: An open system is one which interacts with its environment and can change itself to accommodate the changes in factors like customers' preference, price, product design etc. The adoptability of an open system is judged by its capability in modifying the operational parameters of the system accordingly. It takes input from outside world and exports output to outside world. For example, a Financial Management system can function smoothly even with the change in credit period and credit limit from the banker is said to be having the flexibility to adjust itself with the change the environmental parameters. If a system can accommodate all the changes in the environmental factors, as and when required, is said to be perfectly open system.

1.4.2 Closed System**:** A closed system which does not have any interaction with outside environment. In other words, it functions in the closed environment set and is insular with the change in the environment. A closed system is a self contained one and normally a rigid one. As business environment is subject to change and a business system is expected to adjust itself with the change in the environmental factors. In other words, a business system can not be closed system. In fact, close systems are very limited. Some systems in Military or Defence Service may be closed system because their rules, procedure and factors are set to be rigid for the sake of strict code of discipline.

1.5 Evolution of Information System

The evolutions in Information Systems can be distinctly divided into five Generations of Information System which are as follows :

1. Manual System

2. Mechanical System
3. Electronic Data Processing (EDP)
4. Management Information System (MIS)
5. Decision Support System (DSS)
6. Executive Information System (EIS)
7. Expert System

1.5.1 Manual System (before 1930)

- It was old and primitive
- It involved highly clerical work and chance of procedural errors was high
- Procedure was time consuming and there used to be delay in preparation of reports
- There was no alternative cost-effective procedure

1.5.2 Mechanical System (1930-1955)

- Unit Record Machines came into existence
- Improved Computational accuracy
- Comparative faster data processing

1.5.3. Electronic Data Processing (EDP) System (1955-1970)

- Focus was on volume-oriented applications
- Use of computers improved processing efficiency
- Well defined processing rules
- Development of scientific programming and system designing

In 1979, Richard Nolan suggested a model for evolution of information system which has been widely accepted by academicians and practitioners. The model suggest that the level of data processing expenditure of an organization can be seen to progress through six different stages which are as follows :

Stage	**Activities**
Initiation	The First introduction of Computer System was for cost saving. The job which were repetitive in nature and needed high manpower deployment used to be done in computer. Use of computers restricted to accounting function. Knowledge became barrier for future development.
Contagion	The blossoming of computer application in different areas came in a totally uncontrolled way. This stage became chaotic and many application fail.

Stage	Activities
Control	Senior Managers became conscious about the expenditure and lack of control. Staff are centralized and formal Information system organization started to be established. Application concentrated on saving money, rather than making money.
Integration	The control introduced in stage 3 is slackened in order to introduce innovation. The Information system function was re-organized to allow the specialists to become involved with users in development of systems. Large expenditure was made in core system.
Data Administration	Developments were driven by the organization's demand for information. The business recognized the value and potential of information system. Corporate databases creation started.
Maturity	Planning and organization in Information System got incorporated into development of the organization. Strategy was embedded in decision making.

1.5.4 Management Information System – MIS has an objective to provide best possible timely information with the use of modern sophisticated technology. The strategy in MIS is to exploit the technological tool in ensuring the flow of information of right quality at right time at right place (user's place) for effective decision making. Its important features are :

- It is an improved version of EDP system
- It enables the management to have access to desired set of data only
- It meets information requirement at different levels with pre-defined reports
- It undertake transaction processing for different functional areas
- It provides on-line access to data and efficient reporting system
- It supports routine decision making

1.5.5 Decision Support System – It is a sophisticated decision making model with the help of high powered software to take semi-structured decisions. The basic features of a DSS are :

- It is based on one or more corporate databases
- It must be supported by a set of quantitative models
- It has the ability to solve unstructured problems
- It should have the network computing facilities embedded in the system
- It is used for solution in a complex business situation

- It provides supports to Executive Information system for decision making
- Software at different locations facilitates group decision making.

1.5.6 Executive Information System **:** An Executive Information System is a advanced model of Decision Support System which can take care of unstructured problem situation. It aims at providing information to top executives of an organization who are involved in strategic decision making.

1.5.7 Expert System **:** An Expert system is a knowledge based system which acts an expert in devising solutions. An expert system acts in a specific area only with the support of knowledge database on this specific area. Knowledge data base means structured information stored on previous solution sets in unstructured problem situations. In other words, an expert system operates on previous experience which is stored in a database. Even the present solution devised from the system and the information on its outcome will also be stored.

1.6 Growth of Business Information System

In recent times there has been substantial growth for scientific information system in business system. Modern business managers have perceived the importance of support from good information system in business decision making. The following factors have contributed towards growth of business information system :

1.6.1 Change in Computer Technology**: C**ost of hardware has gone down. Thanks goes to technological innovations. Computing speed has gone up tremendously and storage capacity has increased enormously. The revolution in communication technology induced every activity in the business and society to be under its call. The change in the computing capabilities in Information systems due to technological innovations have brought significant changes in the attitude of the management towards effective use of information.

1.6.2 Fast Transaction Processing**:** Today network technology has brought the concept of intranet in an organization. This has helped fast and accurate transaction processing based on instant updation of information from point-of-sale (POS) and warehouse. Large Banks are using the intranet for having on-line information for exchange and control. Information system in banking service has brought a new dimension in control, efficiency, productivity and profitability.

1.6.3 Customer Support**:** Market place is full of suppliers. Products are flooded from domestic and international supply. The expectations of the customers has increased. They have become more knowledgeable about the quality, cost and availability of the products. A business organization can not survive unless it demonstrates its customer orientation. There has been a trend to manage the total supply chain system through computer system primarily to satisfy customer need and to efficiently control inventory.

1.6.4 Changing Product Technology**:** In the global competition of trade, the technology is fast changing. Innovations are revolutionary. Products have shorter life-cycle. Risk of business obsolesce is very high. Only a good Information system can provide right kind of support with right flow of information for scientific control mechanism and decision making. Business Managers are under tremendous pressure to cope up with the speed of development. The magic tools under IT provide continuous information to update with the changes taking place throughout the world.

***1.6.5 Continuous Improvement Effort* :** Cost Competitiveness and quality improvement are two important aspect on which survival of an business depends. Only continuous efforts with better control mechanism can help to achieve the results. The information system is providing the best support. Is it possible to adopt Just-in Time for Inventory Control without computer based information system? Quality information with the help of computer provides the right kind of database for analysis and corrective measures.

***1.6.6 Strategic Decision Making* :** Business Strategy and Information system of a modern organization is inseparable. A sound strategic decision is based on analysis of various factors – both internal and external. Strategic Analysis model of Michel Porter can provide strategic solutions to business problems based on scientific and comprehensive information data base. The Model is an eye opener to the business world to develop a new generation of information system for spontaneous strategic business solutions.

***1.6.7 Wide Areas of applications in Offices* :** Computers are being widely used for different purpose in business environment to support the cause of business. They are :

- Text management
- E-mail
- Document management with the use scanner
- Communication through network etc.

1.7 Strategic Planning for Development of an Information System

An Information System is developed with a definite set of objectives and plan to achieve them. For development of a better system, change in the management system in regards to accountability, responsibility and control in different functional areas related to system is essential for effective flow of information, decision making and monitoring.

Until most recently, most organizations regarded their Information systems as a resource that is necessary but not strategically significant. The IT department was treated like any other service department and the information system was allowed to evolve rather than being formally planned. Major benefits for formal information system strategy :

- To achieve goal congruence between information system objectives and corporate objectives
- To create and sustain competitive advantage
- To exploit Information Technology to the optimum benefit of the organization

1.7.1 Linking Corporate Strategy with Information System Strategy

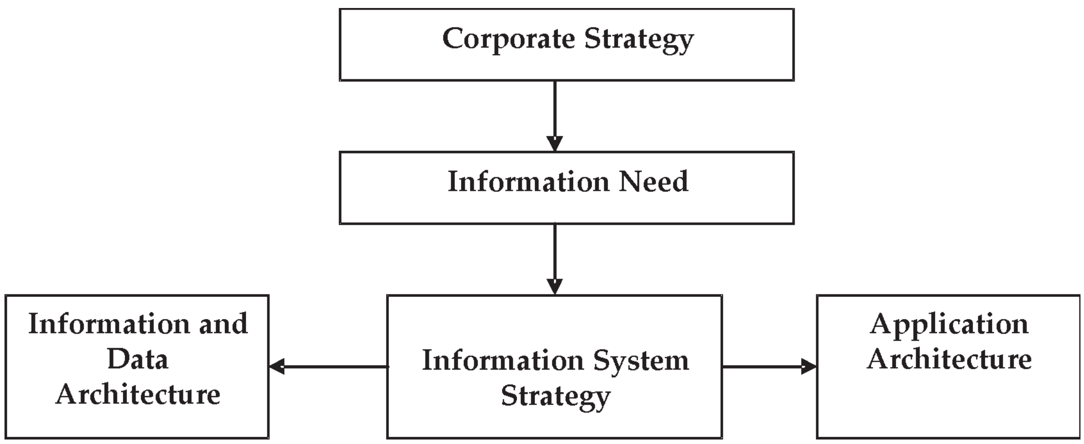
The basic objective of information system strategy is to exploit IT to provide best advantage for the organization.

The following points are to clearly understood before venturing into designing an information system :

1. Identification of sub-systems involved and their interactions
2. Level of Management
3. Decision making process

Today, success of corporate strategy depends on decision making skill. The support of efficient information system needs no clarification. The decisions at different levels of management vary. A standard decision making pattern is shown below :

Level of Management	Decision making on	Information Support from
Lower Level	Operational Control	Transaction Processing
Middle Level	Planning & Control	Management Information System
Top Level	Strategic Planning and Implementation	Executive System Expert System



Information and data architecture :

What is needed is to understand the following :

- Information need for the organization for corporate decision making
- Who will provide the data and who will use it.
- When and how data will be collected.
- How should the data be stored to provide easy access.

Application Architecture

Application architecture development requires the evaluation of the application software requirement in the consideration with the following :

- What application software is required
- What is the most logical sequence of operations

1.7.2 Budgeting and Planning the Implementation details

To plan for future information system the following issues should be critically evaluated :

- Organizations growth plan, business strategy and support needed from Information system
- Information System Budget

- Quality of Human Resources and possible approach to improve their skill
- Applicability of business process re-engineering
- Integration of information from different functional areas

1.7.3 Planning the Operation

To make the information system more effective, the action plan has to be devised for :

- Development of organizational structure in IT department
- Fixation of new role and responsibilities
- Security management
- Risk Management

1.7.4 How to Support the Decision making Process

The important process in the planning is how to improve the use of information in efficient decision making to formulate business strategy. For doing this, through review of the current system and procedure for Information Management is essential which involves the review of the following :

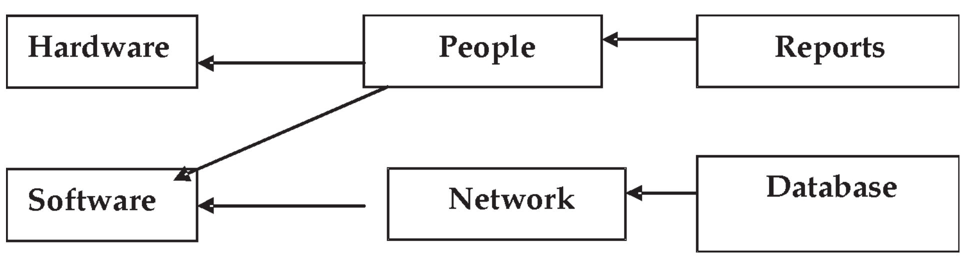
- Current work volume
- Current application software and their life cycles
- Current technology environment and skill level
- Current performance of Information system
- User satisfaction
- Current Business Process and information structure

1.8 Information System Infrastructure

Information System Infrastructure means the physical resources and organizational support required for operation of an information system. It consists of following six basic components:

- Hardware – Devices which store software, database and process data
- Software – Programs process data to generate reports
- Database – Data collected is stored in databases
- Network – Technology for sharing the data and other hardware resources
- People – Human resources to make the system operational.

Reports – Reports are generated by the software with the help of databases for the use by users (people).



The role of information system architecture is to support and reinforce the organization structure and decision making mechanism. If we accept that IT can change the performance of an organization, the real challenge before the management is to ensure the management that the components of IS architecture provides the most suitable solution in the environment under which an organization works. The change management is the most critical issue and change in the architecture should be taken up well before the technology becomes obsolete.

The following exercises are to be made for effective use of resources with the use of technology:

1.8.1 Arranging required hardware and software

Management has to ensure the most suitable hardware and suitable to fulfill the information requirement for decision making. The choice between centralized processing or distributed processing has to be made first. The architecture design is dominated by issue of compatibility of hardware platform and software package.

- Assessment of hardware configuration on the basis of volume of data and type of processing need
- Software requirement in compatible with hardware
- Networking and communication technology requirement
- Assessment of investment requirement and phasing the investment
- Vendor selection
- Procurement plan

1.8.2 Human Resource Management

The system developed by IT specialist often fail to meet the user need. The persons who will be in-charge of development of software must have clear understanding of how the business operates so that technically-perfect solution is evolved. What is needed is personnel involved in Information system must be properly trained on the pattern of functioning of the organization, change needed, plan for changes, stages of transformation and actions plan for the same. The policies of the relevant issues are to be framed to achieve the objectives. The issues are :

- Recruitment
- Training
- Restructuring
- Retention of employees etc.

1.8.3 Implementation

Implementation of infrastructure requires project management skill. What is required is to develop time targets for implementation activities like procurement of hardware, software, allocation of resources and implementation of the system. The time frame may vary from organization to organization for implementation and level of sophistication depends on present system, possibility of skill improvement and acceptance in change in management of the system. Strategies are to be developed for achieving a time targeted system with desired effectiveness. Careful considerations should be taken about the following criteria of an dynamic information system :

- Information needs of an organization change constantly
- The information system should be open and adaptive

- The information system should focus on supportive role in the business process

1.9 Information System Organization

Organization structure should be based on established policy and have well defined rules of responsibilities and authority at different levels. The load of data processing, resource requirement in terms of both manpower and machine must be assessed properly. Job specifications at different levels must be clearly given to avoid gaps in responsibility and performance standard also be rationally established to make the organization more scientific. The objectives of sound organization structure are to provide all possible infrastructure facilities for a good information system. To be more specific, a scientific organization structure for information system means provisions of the following :

- Proper Information Technology environment with right kind of machine, manpower and work culture
- Right resources balancing the hardware, software and skill
- Adequate security system on data, processing and output
- Adoption of scientific and modern software development methodology etc.

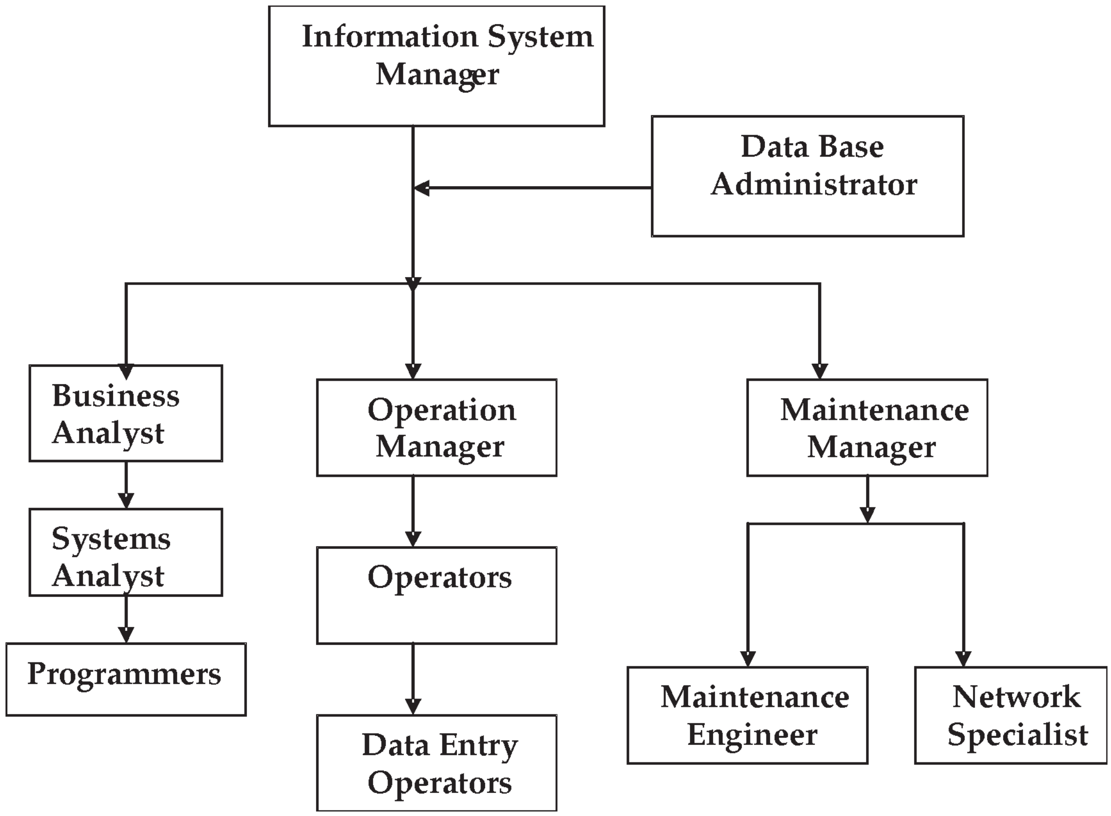
For successful implementation and operation of an information system, organizational set up has to be built to take care certain activities on a day to day basis. Let us understand the activities involved in the information system and the responsibilities of the Information System Department.

The organizational structure of information system in an organization may vary depending on various resources available and their quality but the objectives remain almost same with main focus on effective use of information for better business control.

Activities involved in the department are :

1. System Development
2. Programming
3. Data administration
4. Security management
5. Operation management
6. Quality assurance

The different specialist groups of employees are assigned the responsibilities of the above activities in the Information System Department. The chart below will show the organization structure of a Computer based Information System department :



The following table will explain their activities and responsibilities:

Designation	**Duties and responsibilities**
Information System Manager	• Planning the resources and time frame of implementation • Supervising the overall implementation of system and day to day operation
Database Administrator	• Database Management • Database Library Management • Security of data
Business Analyst	• Development of new Information System. • Acting as co-ordinator between users and IS developers
Systems Analyst	• Analysis of the requirements of the IS, development of system specification • Designing the IS.
Programmer	• Development / modification of programs according to systems specifications and design.
Maintenance Engineer	• Maintenance of Hardware
Network Specialist	• Maintenance of network

Designation	Duties and responsibilities
Systems Operation Manager	• Planning and controlling the flow of data and processing. • Network management. • Co-ordination with users.
Operator	• Computer Operations • Communication network control • Process Documentation • Data Entry Supervision
Data Entry Operator	• Data Entry, Data verification and editing

1.10 Information Systems Personnel Management

Managing the human resources effectively is very critical issue. Success of a Information Sytem depends on the quality of human resources and their support.

The turnover in Information Technology field is comparatively high compared to other industry. Thus, following important issues should be taken into :

- Growth prospect
- Motivational aspects
- Provision for management of gap in skill and expertise

For effective management of human resources, the following policy and procedure must be followed :

1. Job description for different positions should be clearly spelt out to avoid conflict and confusion.
2. Job responsibility for each position should be clearly defined.
3. Recruitment policy must be well defined one to hire right quality personnel.
4. Training programs should aim at skill improvement of the personnel in line with technological change and organization's requirement.
5. Regular screening of security check must be followed to plug all possible motive for fraudulent activities and to avoid risk of any damage.
6. Performance evaluation should be rational, scientific and unbiased to motivate the employees.

1.11 Quality of a Business Information System

Main quality criteria of a business information system are reliability of information, timeliness and correctness of reports. These depend on technology in use, manpower, ethical standard maintained and security of the system. To ensure good quality, system requirements must be properly understood and system infrastructure must be developed.

1.11.1 Reliability of Information : Internet has flooded the information. Today business managers are burdened with analysis of huge volume of information. The exact of relevant information only can lead to sensible use of information. The role of Business Analyst will be of paramount importance with the growth of technological evolutions. There is a saying in computer information system – Garbage In Garbage Out (GIGO). The correctness or quality of reports depends on quality of information. Source of correct data, flow of data and procedure of authorization has to be established.

1.11.2 Processing Time **:** Processing time is an important factor for information system. Information is generated for control in different business parameters in the operation and decision making. Naturally, the time associated with dissemination of information is very important. Information not in time becomes useless.

1.11.3 Matching Management Requirements **:** The information system should be well planned to fulfill the requirement of the management i.e. the owner of the system in terms of time, quality and frequency. At the time of designing the system the reports, contents, formats etc. are to taken care to exactly fulfill the requirements of users of different levels.

1.11.4 Technology : Technology refers to :

- Configuration of computer in terms of capability, security etc
- Software in use
- Communication system – network efficiency
- Type of processing - batch, real-time or on-line

1.11.5 Human Resources : The employees need new orientation in the knowledge of computer products, technological change taking place, expertise to handle these and managerial complexity evolving out of these. They are to develop the skill to develop appropriate IT infrastructure, use effective methods to store and access data and navigate them to properly use them. Quality of human resources is the most important component in an Information System organization.

1.11.6 Ethical standard : Ethical issues relating to employees, customer, supplier etc must be properly dealt with to maintain the right kind of image of the organization. Ethical standard must be maintained in dealing with the information being handled in an organization.

1.11.7 Security : The security of information system must be taken care properly. Here, security means security of information and assets. In an processing environment under network, the system is more vulnerable by unauthorized assess, leakage of sensitive information and sabotage. Loss of assets due to fire, theft, natural disaster must be protected.

1.12 Business opportunities due to Development of Computers

Development in Computer has also evolved following business opportunities for Different Business activities relating to Hardware and Software.

1. ***Computer Manufacturing*** **:** This a function generally taken up by big companies. Earlier days manufacturers used to market their own products. Leading manufacturers in the world were IBM (International Business Machine), DEC (Digital Equipment Corporation), CDC (Control Data Corporation), Burrough, Honeywell, NCR, ICL, Hewlett Packard etc.

2. ***Peripheral Equipment Manufacturing*** **:** Some companies are involved in manufacturing peripheral devices like disk drives, tape drives, printers, plotters, monitors, communication equipments. Leading

peripheral manufacturers in the world are Intel Corporation, Motorola, Texus Instruments, Toshiba, Phillips, Fujitsu, Hitachi, NEC Corporation etc.

3. ***Computer Leasing*:** Earlier days Computer Leasing was a very attractive business. The cost of Computer was high. Users generally were not ready to afford huge investment. Some computer manufacturer and some companies were involved in the business of computers leasing. Lease Rent was high. IBM used to provide machines in lease.

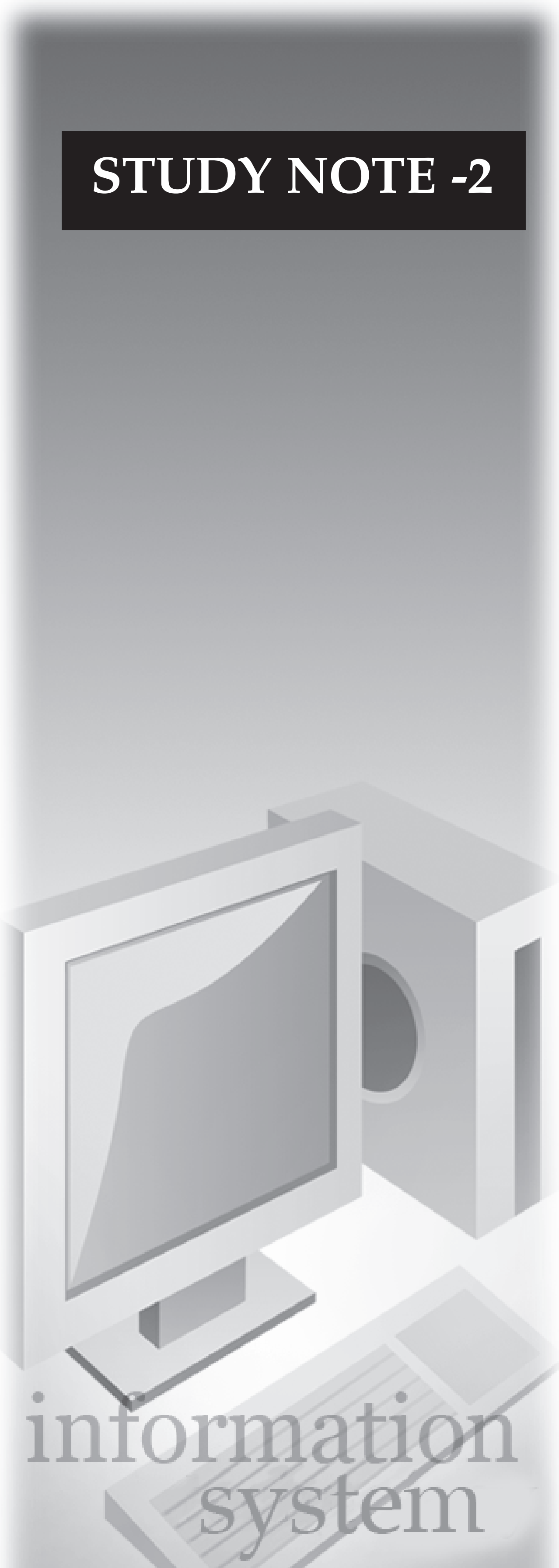
4. ***Software Developers*:** Companies and individuals undertake the responsibilities of developing software for third party companies. The job of contract used to be system designing, program development and system implementation.

5. ***Time-Sharing Companies*:** In earlier days when hardware used to be costly and users were using only selective application systems for data processing, the time sharing facilities provided by different companies on their Computer were found to be cost-efficient and widely acceptable to many users. Some Companies took the opportunities for business purpose. Generally, companies used to buy a mainframe computers with multi-users facilities and charges used to on the basis of usage time of different components like CPU, Printers, Disk, Magnetic tape etc.

6. ***Networking Parlour* :** With the acceptance of networking to be the most efficient communication, use of e-mail and net-working surfing has gone up. It will further multiply when the e-commerce will take a formidable shape to be effectively operative. Providing networking facilities by small shop has become a good business in big and small towns.

7. ***BPO Services* :** The advantages of fast communication though internet technology has opened a new dimension for Business Process Outsourcing of commercial jobs. The data in being transmitted from one part of the globe to other for processing. The same being processed.

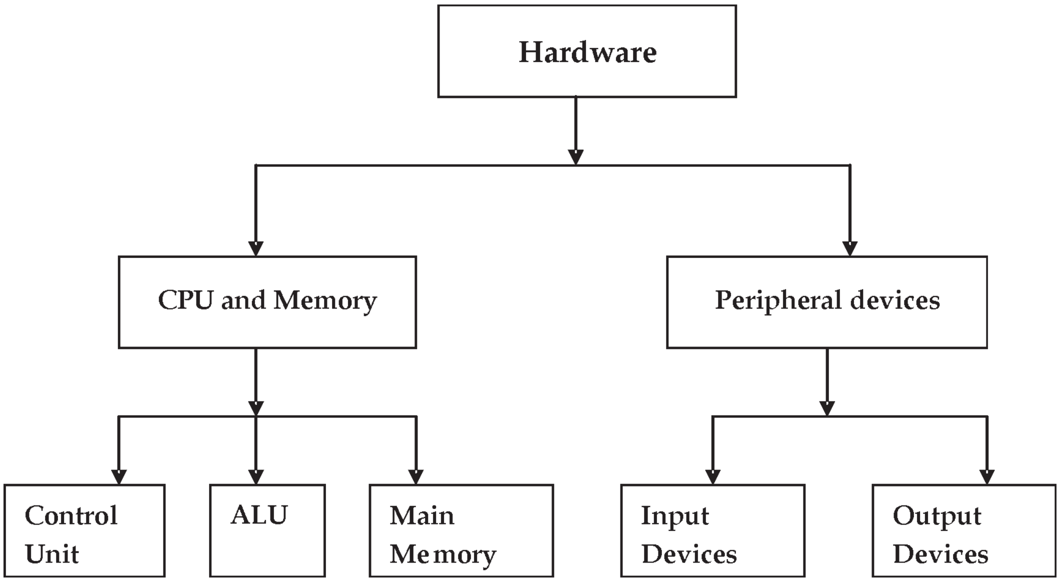
STUDY NOTE -2



Hardware

2.1 Hardware

It is the physical computer device which is used for processing data. Hardware includes the CPU, Key Board, Monitor, Hard Disk, Printer etc.



2.2 Analog, Digital and Hybrid Computer

There are two main type of computers – Digital and Analog. The third is hybrid computer which is a combination of the above two.

Digital computer operates directly on data which is represented in decimal digit form. This data may be number or characters which are fed through input devices like punched card, key board or magnetic media. Digital computers have the ability to handle large volume of data by way of storing them in the machine in the Binary form i.e. 0 or 1, process them and generating reports. Digital computers are used in commercial data processing or work like research mainly in the form of mathematical operations. Example – Any business computer.

Analog computers takes input in the form of electrical pulse. The input are like voltage, pressure, current, water flow etc. The process of feeding data is an analog computer is predefined and operation with the data and the output follows a standard set of guidelines. Outputs are generally a graph or a picture or a table and give signal for control of operation. These computers are generally used in industrial field in controlling various physical parameters or stimulating them to find the optimum solution.

Digital	Analog
1) Operation on number	1) Operation on physical quantities
2) Process data	2) Measures the physical parameter
3) Generate reports	3) Provide control information
4) Discontinuous	4) Continuous
5) Mainly commercial and scientific work	5) Mainly process control unit.

Hybrid computer – It is a combination of both digital computer and analog computer. Generally, in this kind of system data are fed in analog form and output is generally in digital form.

2.3 Evolution of Hardware

As usual, the development of computer has come through evaluation process. The phase of evaluation has been distinguished by quantum jump in technology and they are termed as generations in development process.

1. ***First Calculating Machine (450BC) –*** The Abacus is known to be the fast calculating machine which was invented by a Chinese mathematicians named Abacus. It was very primitive in its look and consisted of a frame and a number of wires.

2. ***Napier's Bone (1550-1617) –*** This was invented by a Scotish mathematician – John Napier. It used rods which were similar to human bones. This gave the rise to the name Napier's Bones. It could multiply the numbers with the help of rods.

3. ***Adding Machine (1623-1662) –*** This was invented by French mathematician Babie Pascal. This machine had the advantage that it could carry digits and used to add digits. The principle used to add numbers were mechanical counters.

4. ***Analytical Engine (1791-1871) –*** Charles Babage, an English mathematician developed this machine, this machine could perform a great deal of calculations. The machine had the following features:-

   - Punch card system as input device
   - External memory
   - Power to do arithmetical calculations
   - With a speed one addition in one second

   These features are fundamental in nature and in true sense had a great pioneering work in the filed of development of computer. For this reason Charles Babage is called the Father of Modern Computers.

5. ***Punch Card Machine (1889) –*** Dr. Hollorith, and American developed the punch card machine. He was involved in the American census in 1890. The result of census used to be greatly delayed those days in absence of sophisticated calculating machine. He devised a card in which holes to be punched. There were wire brasses in the machine. The holes in the card enable the wire to touch a metal plate which carried an electric charge. The charge was transmitted to electric counters, thus the punch cards could help to identify the figures through the difference in charge. Modern punch card machine were developed from it. In modern punch card system there are 80 columns and 9 rows. Unique combination of holes were thought to represent numbers, alphabets and special characters.

6. ***Eniac (1944) –*** This was the first electronic calculator devised by Mark I, scientist of Howard University, USA. It could perform all calculations that a small calculator of today can do with a speed of 300 multiplication per second. But the size of the machine was too big. It needed two rooms to accumulate and its weight was approx. 5 tonnes. It used vacuum tubes.

7. ***Univac (1951) –*** Sparry Rand Corporation of USA developed first commercial computer to be named as UNIVAC I. The name was after universal accounting company established by Ackert and Mauchy.

2.4 Different Generations of Computers ?

Continuous research has resulted a significant development in the evaluation process of computer hardware. The basic objective of the research was to bring improvement in computing power, bring more versatility and reduction in cost. The development process was marked in distinguished jump in technology and each stage is termed as generation. There has been vast improvement in computer system in terms of technology, speed, storage, reliability, size and cost. The table below will give a picture how the development in different generations made a difference in technology and efficiency in computing power.

	1st Generation	**2nd Generation**	**3rd Generation**	**4th Generation**
Technology	Vacuum Tube	Transistors	Integrated Circuit	Large Scale Integrated Circuit
Memory Capacity	10,000 – 20,000 chrs	4,000 – 64,000 chrs	32 KB to 8 MB	1 MB to 128 MB
Internal Operating Speed	Mili-seconds	Micro-second	Nano-second	
External speed - instruction/sec	Few thousands	One million	Ten millions	
Mean time between failure	Minutes	Days	Weeks	
Memory	Cathode Ray tube	Magnatic Core	Magnetic core	
Peripherals	Punch Cards Paper Tape Magnetic Tape Magnetic Disk Magnetic Drum Printer	Punch Cards Paper Tape Magnetic Tape Magnetic Disk Magnetic Drum Floopy diskette Printer VDU	Punch Cards Paper Tape Magnetic Tape Magnetic Disk Magnetic Drum Floppy diskette Printer VDU OCR MICR Plottere	Punch Cards Paper Tape Magnetic Tape Magnetic Disk Magnetic Drum Floppy diskette Compact Disk Printer VDU OCR MICR Plottere
Operating System	Batch Processing	Multiprogramming and time sharing	Multiprogramming and time sharing Real time	Multiprogramming and time sharing Real time Remote processing
Language	Machine Language	Assermbly Language High Level Language FORTRAN & COBOL	FORTRAN II & IV COBOL BASIC ALGOL	FORTRAN COBOL BASIC ALGOL PASCAL PL/1 ETC ADA

	1st Generation	2nd Generation	3rd Generation	4th Generation
Application Area	Payroll	Payroll Inventory Billing Accounting	Payroll Inventory Billing Accounting Market Research etc	Payroll Inventory Billing Accounting Market Research Air Line Reservation etc
Important Computers	UNIVAC – I & II IBM 650, 701 BURROUGH – E101	IBM 1401, 1620, 7090 HONEYWELL 400 BURROUGH – 200 UNIVAC – 1004 CDC – 1604	IBM – 360, 370 ICL – 1900, 2900 UNIVAC – 1100 CDC – 6600 PDP–11, VAX 750 BURROUGH 6700	
Size & Cost	Large Costly High power consumption	Reduced size Increased reliability Less power consumption	Smaller size Less Costly Powerful system Less power consumption	Very Smaller size Less Costly Powerful system Less power consumption

2.5 How a Computer Functions

To function properly, the computer needs both hardware and software. Hardware means the machine i.e electronic and mechanical devices and software means programs. We can see the physical presence of hardware where software is stored in memory or in storage devices. If compared with human, body is the hardware and intelligence is software.

Computer does the following four functions :

- Receive the input data through input devices
- Process the data with the help of CPU
- Generate the output through output devices
- Stores the input/output in storage devices

To understand how it works let us see what are the main components of computer hardware and their functions. The components are broadly divided into CPU, Memory and peripheral devices. Peripherals means input or output devices.

If an analogy is drawn, it will be easy to understand.

Computer System	Human
Computer	Body
Peripherals	Hands & legs
VDS	Eyes
Input/Output devices	Mouth
Input devices	Ear
Control devices	Brain
Memory	Memory

2.5.1 Central Processing Unit (CPU)

The central processing unit is the most important component of a computer system. It is called the heart of computer system.

CPU consists of three components :

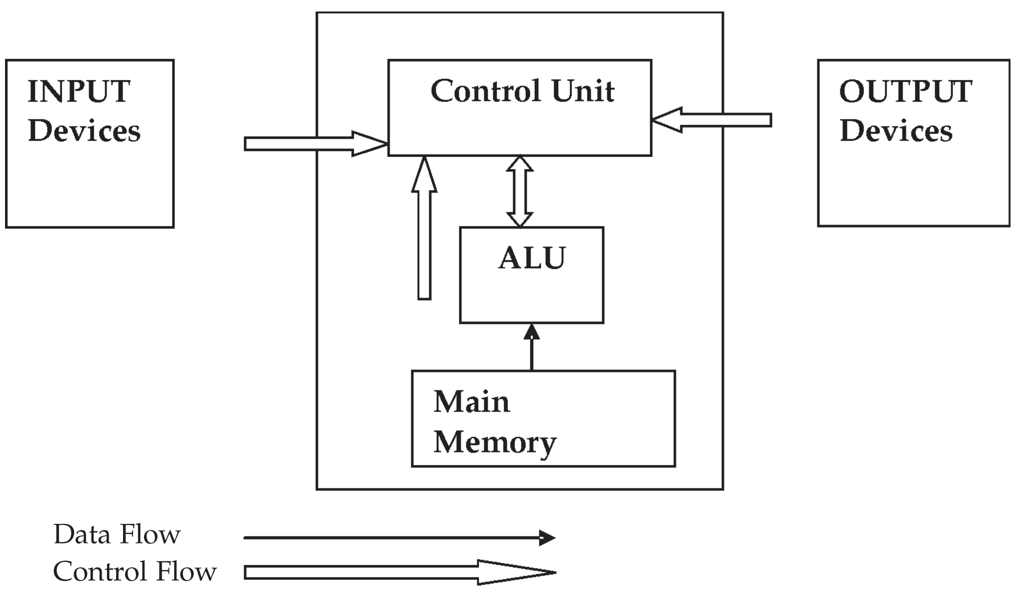
(i) Control units

(ii) Arithmetical and Logic unit (ALU)

To understand how these units function, two terms must be known first. They are Registers and Addresses.

Registers: Registers are storage locations in Control Unit and ALU. They are used to hold data and instructions temporarily. The contents are handled very fast to make processing faster.

Addresses: Each Register is identified by its address. The contents of a register can be referenced in future use by its address. The addresses of the registers are stored in main memory in address-registers, simply called address.



2.5.2 Control Unit

It is the nerve center of the computer system. Its function is to interpret and execute the instructions.

- It controls, supervises all activities of a computer and monitors the execution of programs.
- It coordinates various parts of computer system like ALU, Main memory and Peripheral devices.
- It controls transfer of data from input devices, storage in memory, movement of data from memory to working space and back and finally to output devices.
- Stores programs, data, and results in main memory in separate partition made for them.
- Permits the users to wants to have access to computer simultaneously.

In the first phase, Control unit takes an instruction from the primary memory and stores it into instruction register and interpret the instruction with the help of instruction's operation code table. The time required to perform this is called **instruction time.**

In the second phase, CU actually performs the task as indicated by the instruction. The time required for this is called **execution time.**

The execution of job of CU may involve transferring data from one location to another and/or computation by ALU.

Cycle time = instruction time + execution time.

Cycle speed has gone up with the development of computer. First generation computers used to measure it in terms of milliseconds, the fourth generation in pico-seconds and fifth generation in giga-seconds. Supercomputers execute one billon instructions per second.

2.5.3 Arithmetic and Logic Unit (ALU)

There are three gates in ALU – mathematical gates, logic gates and register.

A gate is an electronic switch. Mathematical gates perform the mathematical calculation, logic gates do the logical operations and register are used for temporary storage of data.

Logical operations are basically comparing, selecting, matching of data whereas Arithmetic operation means addition only. In computer, subtraction is addition of complements, multiplication is repetitive additions and division means repetitive subtractions.

2.5.4 Primary Memory or Main Memory

Primary memory is for storing program, data, and doing the processing. In fact, it can be visualized as consisting of five areas for storing different sets of programs and related data as given below:

(i) Operating System i.e. Supervisor Program

(ii) Program (software) storage area to store program for execution

(iii) Input storage area for holding data from input devices

(iv) Working storage area for processing the data

(v) Output storage area for temporary storage of results as a buffer which are sent to output devices.

Major elements of a Central Processing Unit		
Control Unit	**ALU**	**Main Memory**
Instruction register	Addition	Operating System
Operation Decoder	Subtraction	Application software
Address Register	Multiplication	Input data storage
	Division	Working Storage
	Comparing	Output storage

2.6 System of Storage in Memory

In Computer Fundamental unit of storage is binary digit or bit. Binary means two. Digital computer used magnetic core for memory. These magnetic core are iron-ferrite doughnuts. Binary numbers is represented by a combination of 0 and 1. In Computer memory, "0" and "1" are represented by off and on in the electrical circuit. In digital computers, memory location consists of electric circuits.

A Computer can store data or instructions through electronic switches in the sequences of off and on positions in the memory. All digits, instructions and commands are converted into a sequence of binary digits or bits (0 or 1). Most of the computers today represents numbers, letters or special characters by combination of group of bits.

The most common group of combination is eight-bit group which is called a **byte.**

The memory capacity of computers is measured by kilobytes (KB), Megabytes (MB), Gigabytes (GB).

1 kilobyte = 1024 bytes = 1000 bytes (approx)

1 megabyte = 1024 kilobytes = 1million bytes (approx)

A single byte can store one character only. Thus, number of bytes of computer memory required to store a data item is equal to the number of characters of the data field. For example, ten character name field requires 10 bytes.

However, some of the computers have standardized the number of bytes assigned to a specific type of data. These standards may be different for different manufacturers. Basically, the combination of bytes are used for storing a large number to increase the accuracy (precision). In case of data in scientific research needs higher degree of precision than what is required in commercial application. A computer manufactured for use in scientific research will follow bigger byte group for storage of data and processing.

No. of bytes taken together form a **word**.

Commonly used word length is 8, 16, 32,64 bits. During processing computer uses bits of its word length size. This is why word length is taken as a measure of computing power. The higher the word size, the more is the power of the computer. A 32-bit computer indicates its word size.

Magnetic Core Memory – It is a small ring of ferromagnetic materials which can be magnetized very fast and retain it until changed. It is used to store binary bit 0 or 1.

Semiconductor memory – Semi-conductor memory consists of electronic circuits. It is made in silicon chips. Today all modern computers use semiconductor memory for the following advantages:

- Physical size is small
- High capacity
- Low Access time
- Low cost
- Low power consumption etc.

2.7 Different Types of Memory

***2.7.1 RAM (Random Access Memory)* :** The term RAM itself indicate that this kind of memory allows to reading and writing both possible random access this making it very fast. RAM is volatile in the sense that this type of space is used for temporary working area and contents are lost as soon as the power in the machine is switched off.

There are two types of RAM :

- Dynamic RAM (DRAM)
- Static RAM (SRAM)

The difference in DRAM and SRAM is in technology in terms of holding data. DRAM has to be refreshed frequently (thousands in one sec) whereas refreshing need of SRAM is very less.

***2.7.2 ROM (Read Only Memory)* :** The term itself indicates that this type of memory is used for permanent data storage and allows only reading. ROM's are normally used to store information which is used by the computer for its own operation. Unlike RAM, ROM is not volatile i.e. contents of ROM is not lost as soon as switch of the machine is made off. Computers uses ROM chip to store permanent program for example program for booting the computer. At the time of manufacturing of ROM chip, program is stored.

Difference between ROM and RAM

ROM	RAM
Allows only read facility	Both facilities – Read and Write
Contents are permanent	Volatile – i.e. lost when power is switched off
Contents are fixed which are generally for use by computer for its own operation	It is an working space for the computer.

***2.7.3 PROM (Programmable Read Only Memory)*:** PROM chip is used to store program of permanent nature. PROM is used for microprocessor dedicated for a particular job. At the time of manufacturing, PROM chip remains blank and program is written on it afterwards.

***2.7.4 EPROM (Erasable Programmable Read Only Memory)*:** This kind of ROM is used for storing programs. It is different of PROM in the sense that earlier program can be erased by lesser rays and new program can be stored there.

***2.7.5 EEPROM (Electrically Erasable Programmable Read Only Memory)*:** This is a special type of PROM which can be erased by electrical charge.

***2.7.6 Flash Memory* :** It is a special type of EEPROM where programming is faster (in blocks). Flash memory chip is used only to keep provision of faster updation.

***2.7.7 Cache Memory* :** This is a very fast RAM. It is costlier than the RAM cost in terms of capacity. The basic objective of using it is to do processing faster. It is placed between CPU and main memory. When some information is needed frequently for processing, the same is copied from RAM to Cache memory to have faster access to the contents of cache memory and thus enhancing the speed of processing.

2.8 Secondary Storage Device

The main memory of a computer is limited in size and expensive also. Thus, main memory is never meant for the entire data storage. The data or programs whatever required during processing are loaded into the memory and after processing they are stored back in the storage media for subsequent use. This provision for additional storage space is called secondary storage.

It is like the provision made by the human being. A person can not keep everything in his memory. Something is stored in his note books, files, books etc. He consults them whenever required. Exactly in the same fashion, secondary storage is a space or media in which data or programs are stored for use at the time of need.

The most common secondary storage device are floppy disk, magnetic disk, magnetic tape etc.

Characteristics of secondary storage device :

1. ***Mass storage*** – Large volume of data can be stored. Now in a hard disk, 1 GB to 8GB data can be stored. In a magnetic tape, 150 MB to 250 MB storage capacity is very common.
2. ***Back up provision*** – This is a provision of storing of important data files or software in storage device for protection from damage.
3. ***Non-volatile*** – Data is not lost due to power failure.
4. ***Movable storage media*** – Storage of data in secondary storage device gives a very important facilities that the data set can be ported from one place to another, one machine to another.

2.9 Virtual Memory

Virtual memory is a provision of secondary storage which acts as primary memory. When the size of main memory is less than required size for a program to run, the operating system enables it with the help of hard disk (main storage media). The system followed is breaking the programs and accommodating the part according to the size of main memory available and rest is stored in hard disk. When a part of program stored in hard disk is required for running the program, a part of the program stored in the main memory is transferred to hard disk and the required part is brought to main memory. This process is called swapping.

2.10 Classification of Digital Computers

In terms of capacity, computers can be classified as Mainframe, Mini and Micro Computers.

Mainframe Computer – It is a very big computer with computing power. In a networking environment, mainframe computer is the nodal point of network.

Mini Computer – It is a smaller version of mainframe computer both in size and computing power.

Micro Computer – Micro computers are built with the help of micro-processor chips. CPU, ROM, RAM are in different chips. Earlier days, micro-computers used to have limited power. Today, power of micro-computers have increased enormously.

	Main frame	**Mini**	**Micro**
Computing power	Maximum computing power	Moderate computing power	Built with micro processor chips
Size	Big size	Smaller in size	Very small in size
Operating System	Operating System supporting Multiprocessing or multiprogramming	Operating System supporting Multiprocessing or multiprogramming	Single user operating system
No of peripherals	Large number	Less no of peripherals	Minimum No of peripherals
Cost	High	Less Cost	Low cost
Application	Network Data warehousing	Business Applications Government Department Education etc	Business Applications Government Department Education etc Statelites in network
Example	IBM 5/390	VAX 8200 of DEC	Personal Computer or Workstation

Further, there is another kind of computer which has fastest computing power and huge storage devices – called **supercomputer**. The speed of this kind of computer is measured in terms on nanoseconds and even pico-seconds which can perform 2 billion mathematical calculations per seconds. Example – Y- MP/C90 of Cray Research Inc.

2.10.1 Personal Computer (PC)

Personal computer refers to stand alone mode computer which is fully equipped with own CPU, memory, storage device, operating system and utility software etc. It is based on microprocessor based technology. The use of PCs have revolutionized the computer world today because of its versatility. It can used as purely a home computer or an intelligent terminal or a stand alone system capable of undertaking vast load of processing which has a capacity of a mini computer.

2.10.2 Workstation

Workstation generally refers to an intelligent terminal in a networking environment. Workstations may be any computer linked under LAN also. Sometimes, workstation may be single-user computer with high storage device. The way workstations are being termed these days, it can be taken any computer meant for a unit taking care data entry or data storage load in a system to be a part of a bigger processing infrastructure.

2.10.3 Laptop Computer

A laptop computer is small, lightweight and portable. It has all the features of a PC. Because of compactness in the architecture and limited production, the cost is still high.

2.10.4 Notebook Computer

A Notebook Computer is typically of size of a note book and can be fit in a brief case. It has CPU, Memory, disk drive of same capacity of a PC and a display screen. It is manufactured based on flat panel technology.

2.10.5 Hand-held Computer

It a small computer which can be held in hand. Hand-held computers are also called as palmtops, pocket computers and PDA (Personal Digital Assistant).

2.11 Input / Output Devices Input Devices

Input devices are the machine used for feeding data into a computer. Example: Keyboard, floppy disk, terminal etc

Output Device: Output devices are the machine through which output of processing comes out from the computer. Example : Monitor, printer, floppy disk etc.

There are some devices which can be exclusively used as input device like Keyboard, Card Reader, CD-ROM etc.

Similarly, there are some devices which can be exclusively used as output devices like Monitor, printer etc.

There are devices which can be used as both input and output device. Example: Floppy Disk, Magnetic Tape, Magnetic Disk etc.

2.12 Different Types of Input Devices

***2.12.1 Key- Entry Device*:** It is a device like a type-writer called Key board for data entry. The standard key board is qwerty Key Board. Most of the key-entry system is off-line device i.e. not connected to the central computer.

2.12.2 Punch Card System: This was very popular data entry system in 70's. This system became obsolete now. Hollerith cards were used in electric Punch Machine and the coding used there is called Hollerith code. Punching means making holes on the punch card. Punch card is of 80 columns. The combination of holes in different columns used to indicate different numbers, characters and special characters.

2.12.3 Floppy Diskette System: The floppy diskette is used for data entry and data storage. This system of data entry device is very popular today. Data is entered through the keyboard, video screen displays the information. The advantage of the system are :

- Input data can be edited in the floppy.
- Floppy is reusable.
- Validation of input data can be done at the data entry through programming.
- Messages on the screen are helpful for operators.
- It is electronic device whereas the punch card system is mechanical one and thus more reliable.
- The system is faster and gives high productivity.

2.12.4 Terminal: This system has become very popular today. Most of the computers have terminals. These terminals are used for data entry. Every terminal has a visual display unit with it. The input data are displayed on the terminals. Now a days, data entry is done with the help of user-friendly program. The program displays menu and options can be selected according to the choice of the operator. Data is validated on-line and with the help of master file, typing load can be minimized.

Advantages :

- Relatively inexpensive.
- During entry, data is visual.
- Data goes directly to the computer i.e. no intermediate storage.
- Have advantage of operation from widely dispersed geographical areas.

Disadvantages:

- If the computer goes down, terminals becomes useless.

***2.12.5 Dumb Terminals and Intelligent Terminals*:** A dumb terminal is used for data entry only. It has the facility to communicate data to and from CPU. An intelligent terminal, on the other hand, has the following facilities :

- It has a CPU to control the function.
- It has buffer memory.
- It has the ability to attach the peripherals i.e. floppy disk, printer etc.

***2.12.6 Point of sale (POS) Terminal*:** These are very small terminals like cash register. Under POS data collection system, sales data are entered at retailer place. Retailers requirements are entered and the same information reaches to the warehouse immediately so that distribution of the product can be made faster.

Advantage of POS data collection :

- Facilitate faster transaction.
- Standard procedure of calculation of sales price, tax etc. can be performed readily and the same can be made to the retailer.
- Update of inventory position can be known to the salesman instantly.

***2.12.7 Mouse*:** Mouse is not in true sense a input device. Mouse is kept on a rubber pad called mouse pad. Mouse has a rubber ball at the bottom and two or three switches. Movement of cursor can be controlled with the help of mouse and switches are used for different options. The operator can operate faster by reaching a particular point on the screen and pressing the button. Pressing button is called clicking. Now-a days, the user friendly software or even operating system gives the menu on the screen and operator can activate the required program by choosing the particular option of the menu or a box by simply bringing the cursor to the appropriate point on the screen with the help of mouse and clicking it.

***2.12.8 Punched Paper Tape*:** This system consists of long roll of one inch wide paper. A vertical column of the tape is used to represent a single character. It is rarely used.

Problems in the paper tape:

- Paper tape is not reusable.
- Its capacity is small.

- Paper tape is not convenient for use.
- It is slow in transferring data.

2.12.9 Track Ball: Its function is same as mouse. The difference is that, it is not required to move to control the movement of cursor. What is required is to rotate a ball on the device with the help of thumb to control the movement of cursor.

2.12.10 Joystick: This is device is similar to mouse. The difference is the cursor continues to move in the direction joystick points. To stop the pointer, joystick has to brought back in upright position.

2.12.11 Light pen: Light pen consists of photocells which activates some desired action when the user touches the PC screen with it.

2.12.12 Magnetic Ink Character Recognition (MICR): MICR code is developed by American Banking Association (ABA). The advantage of MICR code is that any document having MICR character can be read by a computer because both manual entry data and data through reading devices are checked to ensure correctness. Another advantage of MICR is that it reduces or eliminates the amount of coding unnecessarily.

2.12.13 Optical Character Recognition (OCR) Device : It is a reading device used to interpret printed, hand-written data directly from source documents. OCR device make use of light-sensing mechanism and laser technology to interpret recorded data. The essence of OCR is pattern recognition. For this reason, the simpler the character front, the more reliable the OCR system. OCR capability of an OCR device is very high i.e. in the range of 2000 documents per minutes. Machine is costly. It is cost-effective only where 10,000 or more documents have to be read per day.

2.12.14 Scanner : Scanner is a very useful device for reading text or documents. The scanner digitizes the image of the document. Now a days, the optical scanner system supports a software – OCR package (Optical Character Recognition Software). The software translate the image into ASCII characters.

Types of Scanner :

i) *Optical Scanner* – It reads text or data with the help of light source and light sensors. Optical scanners are Optical Character Reader (OCR) and Optical Mark Reader (OMR).

ii) *Magnetic Ink Character Recognition (MICR) Scanner* – It reads character imprinted on a document using magnetic ink containing iron oxide. It is generally used in Banking Industry for clearing of cheques.

2.13 Different types of Output Devices

2.13.1 Monitor : Monitor is used to display the data or commands entered through Keyboard, any message, graphical picture, table etc from the machine. It is synonymously called VDU (Visual Display Unit). A digital monitor uses CRT technology. A digital monitor translates the digital signals into analog signals which controls the display. Different adapters are used to have control on video standard. They are:

- MDA (Monochrome Display Adapter)
- CGA (Colour Graphics Adapter)

- EGA (Enhanced Graphics Adapter)
- VGA (Video Graphics Adapter)
- SVGA (Super VGA).

In earlier days, the display unit on the console too small. With the advancement of the technology, the features of the monitors have been developed and it is a very effective unit for communication between man and machine. Rather, advancement and the success of user friendly system could be imagined only after development of monitors. Depending on the ability of displaying matters in colour in the monitor is classified as given below:

***Monochrome* –** One colour for backgound and one colour for foreground. Common colour is black and white. But it can be green and white or amber and white.

***Colour Monitor* –** Colour monitor can display 16 to 1 million different colours.

For example a 8-bit monitor uses 8-bit for each pixel. 8-bit pixel can display possible 256 colours. (256 = 2 to the power 8). More bits per pixel, more will be range of colour combinations. A pixel represents a single point.

Size of Monitor: Common size is 14 inch. Bigger than this is also available.

Resolution: Resolution indicates the density of the pixels. Quality of display depends on resolution.

Popular VDU for PCs

VDU	Resolution	Simultaneous Colour
VGA	640 x 480	16
SVGA	800 x 600	16
	1024 x 768	256
	1280 x 1024	256
	1600 x 1200	256
8514/A	1024 x 768	256
XGA	640 x 480	256
	1024 x 768	256
TI 34010	1024 x 768	256

2.13.2 Printer:

The printer is the device that prints the output of the computer on paper.

Different types of printers available as follows:

Type of Printer	Features	Speed	Quality of Print
Line Printer	The characters of a line is assimilated and printing of one full line is done at a time. Can only print text.	300 – 1200 lpm	Ordinary
Dot Matrix Printer	Each character is created by striking pins on the printer head. Printing is done character by character. Can only print text.	120 – 600 cps	Good
Daisy Wheel Printer	It uses a disk (plastic/metal) on which characters are set. The printer rotates the disk to bring desired character to print. Printing is done character by character. Can only print text.	10 –75 cps	Good
Ink Jet Printer	It spays ionized ink at a sheet of paper. Magnetized plates gives the shape of ink path. Can print text in different fronts and graphics also.	300 dot per inch	Very Good
Laser Printer	It user a laser beam to produce image on a drum which rolls through a toner to print the image on the paper. Can print text in different fronts and graphics also.	1200 – 2400 dpi	Very Good

Impact or Non-impact Printer

Impact printer is the printer which prints by striking the ink ribbon. For example – Dot line printer, Matrix printer, Daisy wheel printer.

Non-impact printer are Ink jet printer, Laser printer, Plotter.

2.13.3 Magnetic Tape

Magnetic Tape used in computer is like the one is used our home tape. Information records in a magnetic tape is kept by a combination of magnetic spots arranged in a number of horizontal tracks. Size of the standard reel is 2400 ft long. But tape of length 1200 ft and 3600 ft are also available. Reading or writing of magnetic tape is done by magnetic tape drive.

Different type of tape drives are:

- Vacuum column drive
- Steamer tape drive
- Cartridge tape drive
- DAT cartridge

Type of Tape	Storage Capacity	Uses
½ inch steamer tape	40 MB – 100 MB	These are used in vacuum column or steamer tape drive. Drives are costly but the tapes are no costly.
½ inch cartridge tape	60 MB – 600 MB	Tapes are cheap and used in cartridge tape drive.
¼ inch	40 MB to 5 GB	Tapes are cheaper and used in ¼ inch cartridge tape drive. Data transfer rate is high.
8-mm tapes	1 GB – 5 GB	They are used is 8-mm helical-scan cartridge tape drive. Data transfer rate is slow.
4-mm DAT	2 GB – 24 GB	They are used in DAT cartridge tape drive. Data transfer rate is slow.

Magnetic tape can be coded in different formats. i) Seven track ii) Nine Track.
Nine track is preferable for the following reasons:

i) 8-bit character code such as ASCII or EBCDIC and parity bits provides better accuracy in reading or writing of tape.

ii) It can store pure numerical data in packed decimal format i.e two numeric digits are in one column of a tape.

Density of magnetic tape is measured in terms of bits per inch (bpi) or character per inch (cpi). Common tape densities are 800 bpi, 1600 bpi or 6250 cpi.

To separate one record from another record, inter record gap (IRG) is maintained in a tape.In fact, inter record gap occupies a good amount of space. To reduce the wastage of space, records are created in blocks whereby some records taken together are recorded as block. This saves lot of space.

There are two marks on the tape. Beginning of tape (BOT) and end of tape (EOT). Header and trailer levels are maintained for verifying the accuracy and compactness of file processing. A file protection plastic ring is available is called read/write ring. Removing the ring means in read only mode i.e. writing is not permissible.

Advantage of Tape :

- Cost effective
- Huge storage capacity
- Easily stored in data library
- Durable back-up media
- Reusable medium
- Fast input/output

Disadvantages of Tape:

- Reading a specific record is to be done by a time consuming sequential process.
- Data transmission is slow in comparison to disk.

- File protection is lost if the write-protection ring is with the tape.
- Variations in tape densities causes serious problem in portability. Tapes recorded at a very low or very high densities sometimes are not readable by other tape drives.
- File updation (record insertion or deletion) is not possible on the same tape.
- Tape rewinding is a must for dismounting.
- Difficult to recover the files from parity error or physical damage of tape.
- Data can be accidentally erased or overwritten.

2.13.4 Hard Disk

Magnetic Disk consists of circular metallic plate coated with magnetic oxide. It resembles with gramophone record which can be mounted on a spindle. Recording is done on both sides of the plate. The set of disk plate and spindle is called disk pack.

The term hard is used to distinguish it from soft disk i.e. floppy disk.

Disk Pack is mounted on a disk drive for reading from writing on it with the help of a read - write head attached with the disk drive. The read-write heads are attached with a common access arm which moves the read-write heads simultaneously to the position of the disk where reading or writing takes place.

The read-write heads of a magnetic disk do not touch the recording surface. There is a very small gap between the read-write head and the recording surface which is called head's fly height. If the read-write accidentally touches the surface or the gap of head's fly height gets jammed by any microscopic particle, the entire disk pack gets damaged and we call it as head crash.

Types of Disk Drives :

i) ***Exchangeable*** **–** This type of disk are replaceable. Once the work on a particular disk is over, it can be removed and another disk can be mounted.

ii) ***Fixed Disk*** **–** This type of drive is permanently mounted in the computer. This is also called Winchester disk. The term Winchester came from the place Winchester where this type of drive was first developed.

How recording is done in a magnetic disk

On the surface of the disk, there are concentric circles called tracks. Data characters are coded into bits and written on the tracks. Like magnetic tape, magnetic disk also use parity bits for accuracy of data. Beginning bit and ending bit of a character are marked but there is also inter-record gap as in the case of magnetic tape. One track is divided into number of sectors having same capacity. In a disk pack, let us assume

Recoding surface = 10

No. of track in each surface = 200

No. of sector in each track = 19

Then, total No of sectors = 10 x 200 x 19 = 38,000

In a disk, each record has a unique address in terms of sector. With the help of unique address, it becomes easy to fetch a particular record. This is why, disk is called Direct Access Sector Device (DASD).

2.13.5 Floppy Disk

Floppy disk is also soft disk. It is smaller version hard disk and has advantage of handling and portability. It has two different sizes – 5 ¼ inch and 3 ½ inch.

Type of floppy	Storage capacity	Description
5 ¼ inch	360 KB or 1.2 KB	Common density in use – double density and high density.
3 ½ inch	720 KB or 1.44 MB	Size is small but capacity is higher.

2.13.6 ZIP Disk

These are high capacity floppy disk like device. It is little larger than 3 ½ inch floppy disk and thickness is almost double of floppy disk. Their capacity is 100 MB. Because of its small size and high capacity, its popularity is on rise. The technology of laser beam has made it possible to write data in tiny pits. To read the data, laser beam is used to scan the same. This laser technology has evolved optical disks for use in computer. Two popular types of optical disks are CD-ROM disk and WORM disk. The advancement of laser technology may bring revolution in data management in Computer system in future.

2.13.7 CD-ROM Disk

Its full name is Compact Disk – Read Only Memory. The name itself explains that the data are stored can be read only. For reading the data fron CD-ROM, a laser scanner is required. CD-ROM drive supports the same and for that reason it is costly. It is popular because of its high capacity which is 630 KB – 1 GB.

2.13.8 WORM Disk

The term stands for write-once, read many. These are metal film disk on which data are written with the help of laser. In fact, the difference between CD-ROM and WORM is that WORM allows to write once for the first time. Subsequently, the behaviour of both is same.

2.14 Selection of a Computer System

2.14.1 Criteria of Selection of a Computer:

Following criteria should be considered for selection of a computer:

i) Workload – data processing requirements in terms of volume, frequency etc.

ii) Operating system capability.

iii) Type of application system to be processed.

iv) Processing requirements – batch or on-line or distributed data processing etc.

v) Network requirement.

vi) File/data base design support – their special features.

vii) Software performance, capability and special features.

viii) Required data reliability, security and integrity.

ix) Reputation of manufacturer.

x) Reliability of machine.

xi) Cost of machine, delivery, installation.

xii) Maintenance cost etc.

2.14.2 Procedure of Selection of Computer

The selection of computer should follow a systematic procedure to assess the performance of computer, matching the requirement specifications of user, reliability and cost. The standard procedure is:

i) Preparation of design specification.

ii) Collection of offer from vendors.

iii) Conducting benchmark test to understand performance.

iv) Preparation of comparative statement with the following:

v) Benchmark test results

- Configuration
- System software features
- Cost
- Maintenance provisions
- Other terms

vi) Negotiations with vendors, if required

vii) Decision on selection of vendor and fixation of schedule of installation

2.15 Hardware Procurement

Hardware may be procured with the following options:

1. Outright Purchase
2. On Rent
3. On Lease
4. Hire Purchase

Outright Purchase option are generally practiced in India. The advantage in outright purchase is flexibility in the use of the machine according to the need of the organization. Moreover, tax benefit on depreciation is another point which encourages the users to go for outright purchase.

Hardware is procured on rent for the following advantages:

i) Cash outlay for procurement is avoided.

ii) Rent is allowable expenses for tax.

iii) Risk of obsolescence is not with the user.

Procurement on Lease is opted in case of machine is of high configuration and seller is generally the manufacturer.

i) Cash outlay for procurement is avoided.

ii) Lease charges is allowable expenses for tax.

iii) Risk of obsolescence is with the lessor.

Hire Purchase option is normally not used as Computer becomes outdated very fast. This option is exercised only to avoid immediate investment for procurement.

2.16 Installation of a Computer System

The following arrangement/facilities must be made for installation of a computer:

- Site preparation with sufficient accommodation for machine and peripherals with flexible provisions
- Good height of the room.
- Proper electrification.
- Fire protection arrangements.
- Air conditioning.
- Provision for controlling temperature & humidity.
- Protection from dust .
- Proper environment control – free from air pollution, noise, excessive vibration, electromagnetic effects etc.

2.17 Hardware Maintenance

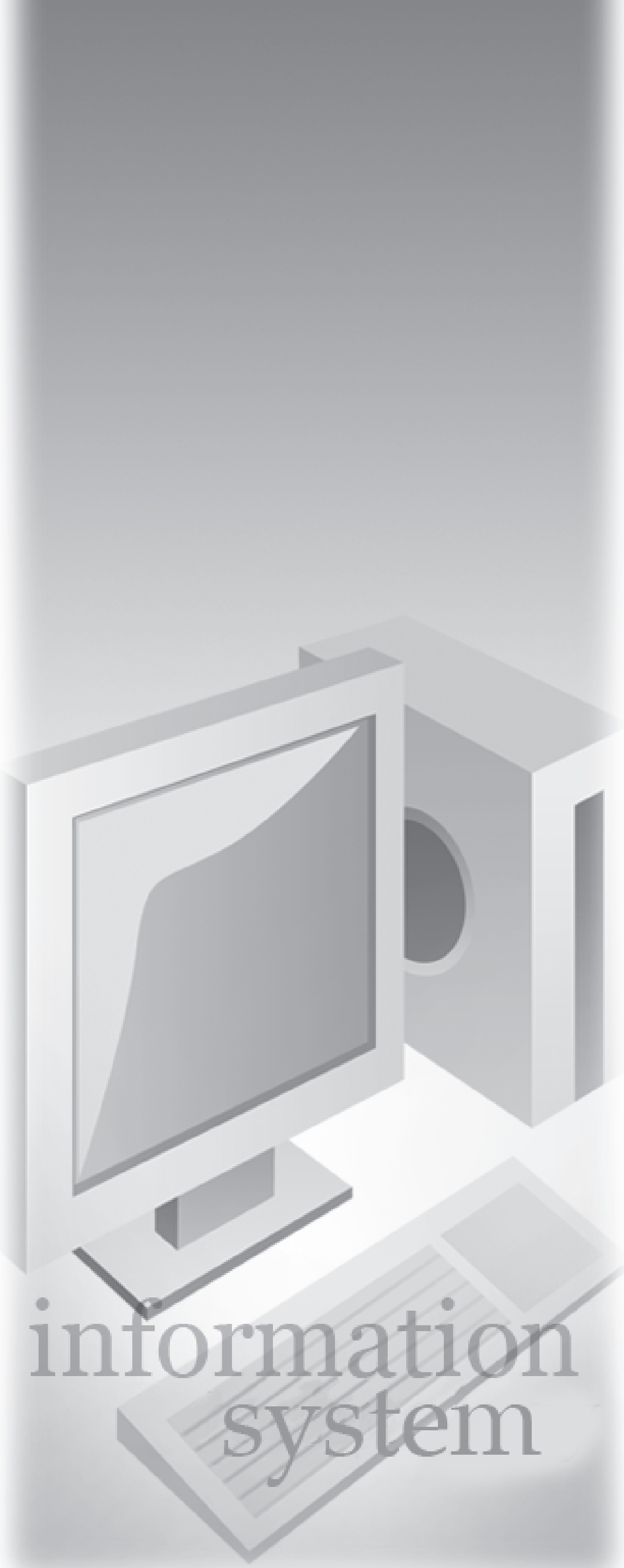
Hardware maintenance means maintenance of computers, peripheral devices and network facilities. Maintenance may be Preventive Maintenance or Breakdown Maintenance or Replacement Maintenance. Maintenance cost is also a consideration. In case of hardware maintenance, proper care is taken to preserve the data in the computer.

Preventive maintenance means provision of mandatory maintenance with certain periodic interval as a precautionary measure to reduce the risk of failure or breakdown of computer. The interval may be a week or a fortnight or a month. The interval is selected depending on the recommendation of manufacturer, sensitiveness of failure etc.

Breakdown maintenance means maintenance after actual breakdown of the computer. The failure of a particular module of the computer or the peripherals are diagnosed in a systematic manner and generally cards or chips or parts are replaced to put back the machine in working condition.

Replacement Maintenance involves replacing major devices of the computer. This happens when that device becomes bad or the same needs up-gradation. In case of replacement, proper back-up of old data files and restoration is a important consideration.

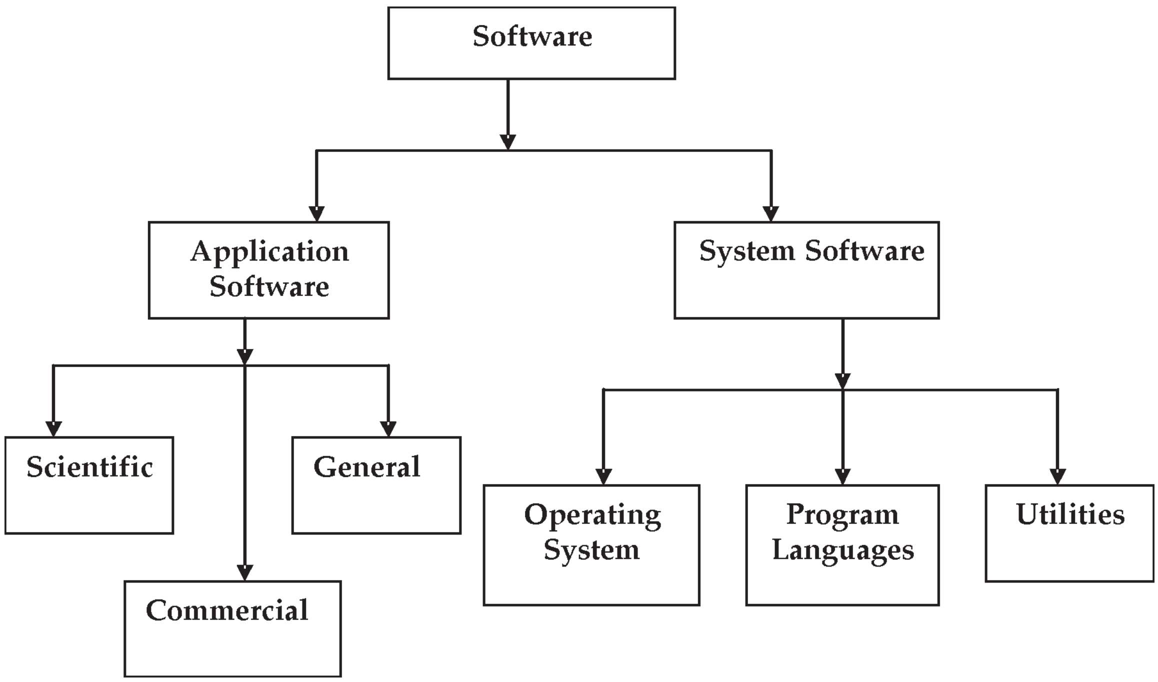
STUDY NOTE - 3



Software and it's Tools

3.1 Software

Software means program. Generally, the term software indicates a software package that is a set of programs which in combination does a particular job. Without software, the computer hardware cannot function. Software actually activates the hardware to work.



3.2 Computer Program

A computer Program is a set of instructions given to the computer to perform a job in orderly fashion. A program is developed in a particular language. The language has a set of command words and special grammar for construction of commands. Writing a program means writing the commands in the sequence of flow of logic of the program.

There are basically two types of software – System Software and Application Software.

3.2.1 System software is the type of software which controls the function of computer system. It may a group of software used for managing the different functions of Computer system e.g. allocation of resources to different jobs, control of input/output, device management, memory management, translation of programming language to machine language, command interpretation etc.

The categories of software which are termed as system software are :

- Operating System
- Utility programs
- Programming Languages etc.

3.2.2 Operating System : It is a collection of programs designed to maximize the working capability of a computer, by way of scheduling and supervising the execution of programs, allocating storage and input/output devices and handling errors etc. Operating software may be defined as a set of programs developed to control the execution of other programs like application programs or utility programs.

Example of some popular Operating System :

Microsystem - Windows, DOS, OS/2, Lunix etc.

Minicomputer – Unix, OS/400

Mainframe - MVS

Following are the functions of the operating system :

- ***Job Management*** – The function includes scheduling of job, activation /deactivation of processes involved in the job. This is done on the basis of algorithm of scheduling and availability of processor and main memory for carrying out the job.
- ***Memory Management*** – This involves allocation of main memory space to different jobs and keeping track of it.
- ***Device Management*** – It involves tracking the status of devices, allocation of various devices to jobs, activate them when needed.
- ***File Management*** – It involves efficient allocation of separate space for each file, arrangement of protection from loss of data etc.
- ***Interaction with operators*** – Interpretation of commands from operators, display of error / interruption massage etc
- ***Security*** – Function of protecting unauthorized access to system. For this purpose security mechanism through password is followed.
- ***Job Accounting*** – Keeping track of time and resources used by different jobs etc.

Classification of Operating Systems

Operating System may be classified as :

- ***Multi-user*** – It allows more than one users at a time. Example MVS, Unix etc.
- ***Multi-processing*** – This kind of OS has the ability to process more than one process at a time by allocating multiple CPU's to different processes. The competitive resources are allocated to different processes depending on their availability. If the resource is not available, it is kept on the hold status.
- ***Multi-tasking*** – This kind of OS allows processing of more than one program at a time. The only CPU in the system is allocated to a task when others are allocated peripheral devices to do Input/Output job. Example Unix, Windows NT etc.
- ***Multithreading*** – This kind of OS allows different parts of one program to run concurrently.

Bootstrapping

Bootstrapping means loading Operating System in Computer after the power is switching on. Bootstrapping instructions are stored in RAM. Once the power is on, the computer takes the instruction of bootstrapping from ROM and loads the Operating System from Hard-disk into RAM and put the computer in opetration.

3.2.3 Utility Software: These are basically to do some routine jobs of specialized in nature which enhances the performance of the computer and /or serve a great utility function to the users.

Examples of Utility software :

- Sort/Merge software
- Editing software
- On line debugging
- Report generator
- Query language etc.

3.2.4 Programming Language: Programming Language is the coded language understandable by the Computer. How a Computer understand the programming language. A Programming Language is developed with its own grammar and features of mathematical tools to handle data. The efficiency of a programming language depends on its versatility of use in handling different problem situations, data handling capacity, file handling features etc. Today high level language or fourth generation language is the result of extensive research in developing programming to make programming more efficient and its use universal. Let us understand the track of development of programming languages.
A Computer understand only 0 and 1. In the early days programs used to written using 0 and 1. Job of machine was very simple to understand the program. But the skill requirement of programmer was higher and writing program was very difficult job.

3.2.4.1 Machine Language : Programming language was of some codes with 0 and 1 only. That was only

Machine Language Structure :

Operand Code	Operand

In case of arithmetic operation, the structure was

Operand Code	Operand 1	Operand 2

way to make machine understand the program. The job of a programmer was difficult and tedious. Of course, codes were limited in numbers and language had a rigid structure. The biggest difficulty was in referencing the operands (variables) by their address locations.
The operand code was a binary code and operands were memory locations.

Machine Language was machine dependent.

Then the thought process of using some standard code for mathematical operations came and assembly language was developed.

3.2.4.2 Assembly Language : It is called low level language. Structurally it is similar to machine language but with some development. Operand code were symbolic and location for operand could be given a symbolic name. For this reason it used to called as symbolic language. It was also machine dependent.

Operand codes were like

ADD for addition

SUB for Subtraction

MUL for multiplication etc.

3.2.4.3 Assembler : A computer can execute only statements written in machine language. Thus programs written in machine language is easily executable. But programs written in Assembly language or High Level Language needs conversion into machine language. The Conversion job of programs written in Assembly Language is done by a software called Assembler. Assembler does direct translation of Assembly program to Machine Language Program.

Advantages of Assembly Language :

- Operand codes are in symbol. Thus it is easy to remember.
- Programmer need not to keep track of memory locations.
- Fewer instructions in the language with simple structure – easy to learn.
- Debugging is simpler.

Disadvantages of Assembly Language :

- Program is very long
- Processing is slow
- It lacks portability

3.2.4.4 High Level Language (HLL) : High Level Languages were developed in such a fashion that the instructions are alike to English Language so that following the instruction codes and writing programs become easier. This helped the programmers to overcome the shortcomings of low level languages to a great extent. The following are the features of High Level Languages :

- They are English like Languages and easy to learn.
- Standard sets of words and well defined structures are used.
- Program development effort is less.
- Debugging is easy.
- Portability is high.
- It is not machine dependent.
- It was procedureoriented thereby reducing programming effort.

3.3 Compiler

Programs written in HLL is called Source Program. Corresponding to each HLL, there is a software called compiler. The task of compiler is to convert the Source Program into Machine Language Program to make it executable. It does it in two stages.

In the first stage, it checks the syntax errors in the program and prints all syntax errors which are called compilation errors with error codes. These errors are corrected by the programmer. Once the program is free from errors, an object program is generated.

In the second stage, from the object program machine language program is generated. The process of conversion from Source Program to Object Program is called compilation.

Compiler translates the whole program in one go. Unless the whole program is free from errors, conversion from source program to object program is not possible. Once the executable program is generated from the source program, the same is used for execution. In fact, the major difficulties of low level language programmer have taken over by the compiler.

3.4 Interpreter

It is a type of translator from source program to machine program. Interpreter translates the source program during execution line by line. When a program is executed under an interpreter, the interpreter checks the correctness of a line in the program and if a line is found correct, it translates the line for execution. If the line is found incorrect, the interpreter displays the line and type of error and stops execution. This process slows down the execution process. For each run of the program, the interpreter has to repeat the process of interpretation.

Even if a program is successful in running once, it does not ensure complete correctness of the program as far as syntax errors are concerned. The reason is that during the earlier run, the program might not have not encountered a condition and have not executed some lines or a subroutine where there may be undetected errors. In the subsequent runs, by encountering some other logical condition the program might have to execute some other lines or some other subroutine in the program and errors may be detected during that point of time.

The cost of interpreter is much less than the compiler.

3.5 Difference between Compiler and Interpreter

Interpreter	**Compiler**
Translates line by line.	Translates the whole program.
Translation takes place during execution.	Translation of whole program in one go.
Execution time is high.	Execution is fast.
Requires less memory.	Requires more memory.
Successful run for sometimes does not guarantee full correctness of the program	Compilation is very time consuming process.
Cost of interpreter is less.	Cost of compiler is high.

3.6.1 Problem - Oriented Language – The focus of this type of programming languages is solving problem. Programs developed in this type language takes data and prints output. RPG is a typical Problem-Oriented Language.

3.6.2 Procedure-Oriented Language – COBOL is a procedure oriented language. A program can be broken into modules and for each module a procedure can be written.

3.6.2.1 COBOL – Common Business Oriented Language

COBOL was developed by a committee of conference on Data System Language (CODASYL) in 1959-60. Latest version is COBOL–80. It has been widely used all over the world. COBOL has the following features:

- It has four divisions
  - IDENTIFICATION DIVISION
  - ENVIRONMENT DIVISION
  - DATA DIVISION
  - PROCEDURE DIVISION
- The different sections under different divisions have special function.
- The instructions in Procedure Division are almost similar to English Language.
- Provision of separate procedure for separate sub-module is a good feature of modular programming.

Advantages of COBOL:

- Easy to learn
- Very close to English Language adding self documentation features
- Most suitable for commercial applications
- Supports features of Structured programming
- Good capability of file handling
- Procedure-oriented language helping modular programming

Disadvantages of COBOL:

- Program is lengthy
- Not suitable for scientific or mathematical programming

3.6.2.2 BASIC – Beginners' All-Purpose Symbolic Instruction Code

It was developed by John G Kenedy and Thomas Kurtz, Professor of Mathematics at Dartmouth. This is very simple language and it is suitable for both scientific and commercial applications. A statement is written in a line and line number is assigned to each statement. Flow of control is managed through line number.

Advantages :

- Easy to learn
- It is supported by both Interpreter and Compiler.
- Has a good debugging facilities by throwing syntax errors at the time writing program
- Statements are very compact

- Simpler read/write statement
- Arithmetical statements are simple algebraic equations.
- FOR – NEXT loop and simple sub-routine structure has made the program very versatile.

Disadvantages of BASIC:

- Has limited capability file handling
- Does not support ISAM file
- Not suitable for Structured Programming

3.6.2.3 Fortran - Formula Translation

The language was developed by IBM (International Business Machine) in 1957. There has been continuous development resulting FORTRAN II and FORTRAN IV, FORTRAN 77. Main features are :

- Statement number is optional. This is adopted to control the flow of program.
- Easy handling of arithmetic operations.
- Data definition provision fixes the size of variables ensuring more precision in results.

Advantages of FORTRAN :

- Easy to learn
- Efficient in mathematical problem solution
- Generally, machine dependent

Disadvantage of FORTRAN :

- Has limited capability of file handling
- Not suitable for commercial application
- Does not support ISAM files
- Not suitable for structured programming

3.6.2.4 PASCAL :

PASCAL was developed by Nikolas Wirth and named after the Great French inventor of Computer, Blaise Pascal.

- It has the structured programming
- It does not support the statement GOTO thus allows GOTO-less programming
- Has good ability of both file handling and mathematical calculations.
- Useful for all types of problem solutions.

3.6.2.5 ALGOL

ALGOL (Algorithmic Language) is basically developed for mathematical problem solving. This language supports features of structured language. The Language also supports features of dynamic allocation of storage.

3.7 Fourth Generation Language (4 GL)

The technology of software development has undergone revolutionary changes. With the evolution of sophisticated hardware, the usage of computer has expanded far and wide. To make usage of computer more popular, the tools of software development has been made simpler. Development of wide varieties of data structure is a part and parcel of the evolution process. To reduce the burden of programmer, programming language evolved some user-friendly tools. Like the evolution in hardware, programming language is undergoing developments which has conceptualized as generation in terms of features, capability and technique. The Fourth generation language are bracketed as the languages which have the following features:

- It is a combination of simple commands and simple structure.
- It includes decision support facilities with simple what-if structure.
- It supports tools to develop user-friendly software
- It has facilities of easy handling of databases

3.8 Some General Software Features

Now a days, software are being development with broad based features for general use and thus they become complex. Apart from it, keeping in view the size of the application and the cost , an application like ERP may have four versions – desktop, standard, professional, enterprise etc. The software are to be user-friendly, network friendly and so on. To add these features is not simple. Some common features of today's software are given below :

1. Graphical User Interface (GUI) – Easy to use. For example for copying a file in window, only dragging the file from source to destination will do.
2. Network capability – It is the capability of running the software with the users in the network from the server.
3. Web enabling - Availability of updates of the software to the users through internet connections. For example, users can have more images from Microsoft website via internet connections.

3.9 Advanced Programming Languages

C +

C+ is developed version of Language C. It is a structured language and supports features for development of structured programs. It is commonly used for system programming because of facility to have access to machine level information through pointer, union etc.

Advantages of C+ :

- Program performance is very high in terms of speed of execution
- Structured Language
- Facilities of low level access
- Supports a good number of standard librabries etc.

Disadvantages of C+ :

- The syntax sometimes becomes difficult to understand.
- The compiled program may have bugs and cause devastating results. A very unsafe programming language.
- Understanding program logic from a program sometimes becomes difficult for debugging.

3.10 Visual Programming Language

Programming Languages which can use graphical features has become very popular these days for developing user-friendly software.

3.10.1 Visual Basic (VB)

Visual Basic is a powerful language to develop GUI based programs in Microsoft Window Based system. It is evolved from the original BASIC language with GUI features making it a very simple and user friendly software. It has also the special feature of integration with COM components written in other languages. COM components can also be linked to / embedded in application's user interface.

Advantages :

- It is a simple Language
- It has comprehensive on-line help facilities.
- It supports GUI features
- It supports the facilities of integration of COM components written in other languages.
- It has Object Linking and Embedding (OLE) facilities.

Disadvantages

- Programs written in VB is slower and less robust.
- VB programs has limited portability in Windows environment
- It has very limited access to library.
- OLE Object Linking and Embedding needs large amount of memory.

3.11 Object Oriented Programming

Object Oriented Programming is a way to organize data and code within a program. Object–oriented representation is a powerful technique for dealing with a complex system. Three main features of Object–oriented programming are :

- Encapsulation
- Inheritance
- Polymorphism

Object : An object is a basis entity in a system. Every object consists of an attribute and one or more methods. An attribute can be any property of the object. A unified entity or item can be viewed as an object. A person or city or cars can be viewed an object.

Class : Class refers to the definition of the object. Class helps in making the entire set of data and code into a single user defined data type. Once a Class has been defined, a number of objects that belong to the same class can be created.

Attributes : Attributes characterizes the object and are identification criteria for an object. For example Name, Phone number, Address are attributes for a person which is taken as an object.

Methods : Methods are functions and procedures that are used to perform actions related to the object.

3.12 Oracle

Oracle is a object Relational Database Management System (ORDBMS). Object can be defined as re-usable software codes. Oracle is based on a concept of 'Client/Server Technology'. Under this technology, it has to perform both the activities – database server and interaction with application client.

Tools of Oracle are :

- SQL * Plus – standard database language for storing and retrieving data
- PL/ SQL – Procedural Language/SQL.
- Forms – designing report
- Reports - output generation

Features of Oracle

- Ability of breaking table into smaller to reduce the risk of loss of data
- Provision of high data integrity
- Allows multi-user access to databases with explicit locking of data
- Ability to retrieve data spread over multiple tables etc.

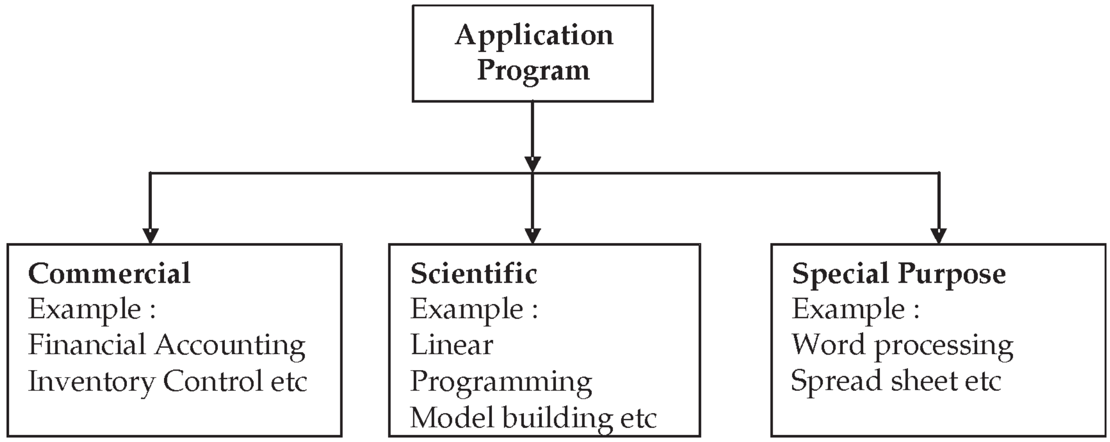
3.13.1 Virus

It is a software which is directed to destroying software or information in a computer. It is generally carried along with a program or data through a device without the knowledge of the user. The virus software is activated at encountering a particular situation either in terms of time or action. It gets multiplied automatically that means it gets copied from one file to other in an attempt to make the damage wider. There are varieties virus and their actions are different. It destroys software, data file and even file allocation table (FAT).

The virus software was developed to interfere with free exchange of program in order to make the users to buy software by paying due price for it to protect the interest of software developers. But its subsequent indiscriminate use has gone beyond ethics to affect the resources and free exchange of programs among the users.

3.13.2 Anti-virus

It is again a software to neutralize the effect of virus in the machine. It first detects the presence of a virus in a media and then removes the virus from it. Anti-virus program has a pre-defined ability to detect or correct against a range of viruses. Virus is like an infection and anti-virus is like a drug. There is tug of war



in the development process of virus and anti-virus and it has become a good source of business. There is a need for continual up-gradation of anti-virus software to counteract virus. The best process of virus control is to have sufficient preventive measures in importing software and files into a machine.

3.13.3 Virus Scanning

This is a process of continuous checking of possible encroachment of virus in a machine with the help of a set of anti-virus software called anti-virus tool-kit. Scanning provides safety to the software and data files but its negative effects are :

- It slows down the processing
- Requires continuous up-gradation of anti-virus software
- It involves cost
- It does not guarantee against the damage by new virus

Measures for Virus control : Following are the measures :

- Virus Scanning
- Up-gradation of anti-virus tool-kit
- Restriction to access by unreliable and unauthorized users
- Restriction of copying unauthorized software (Game Software etc) which are major carriers of virus.

3.14 Application Software

An application software is developed to do data processing work according to the need of a particular application area, be it commercial or scientific or otherwise. An application program can be called or dedicated software for a particular work.

Major areas of Commercial Applications:-

- Payroll
- Inventory control

- Financial accounting
- Sales accounting
- Production control
- Purchase accounting etc.

Example of Mathematical package for Scientific, Engineering applications :

- Statistical Analogy
- Multiple Regression Analysis
- Linear Programming
- Simulation and modelling etc.

Example of Special purpose Application Software

- Nursing Management in Hospital
- Air-line Reservation
- Railways Reservation etc.

Firmware : Firmware or micro-programs are a series of special program instructions. They basically deal with low-level machine instructions to be carried out by different circuits. For this reasons, this type of programs are referred as firmware.

3.15 Applicability of Program Language

The applicability of the Program Language depends on the type of application. The features and coding structure of a program language are more suitable to meet the requirement of some category of users which are given below :

For Scientific and Engineering application

BASIC

FORTRAN

ALGOL

APL

For Commercial Application

COBOL

RPG

BASIC

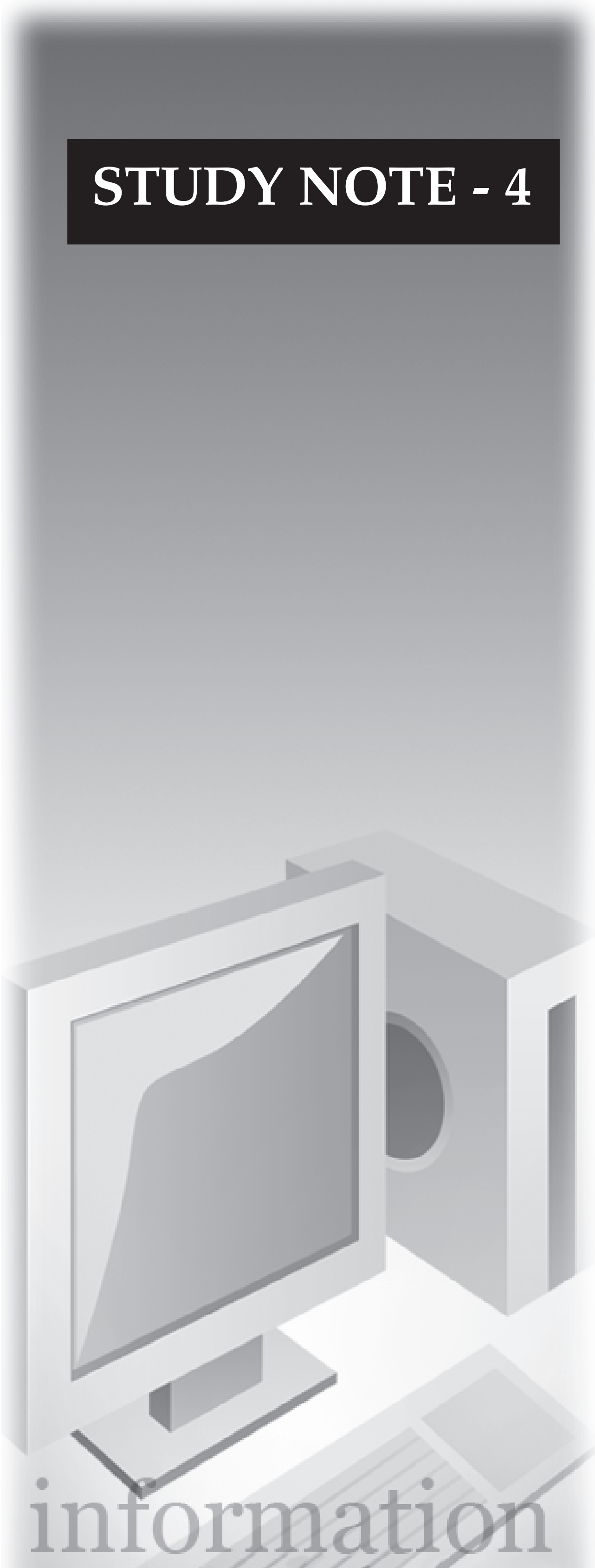
For General Purpose

PL/1

PASCAL

ADA

STUDY NOTE - 4



System Development Cycle

4.1 System Development

System development process involves three major steps – System study, system design and program development. In fact, a business system is not developed so simply. For a business system requirement has to be studied, mode of processing has to be decided, system architecture has to planned, cost-benefit analysis has to be made, management approval is to be obtained and the following detailed steps are followed one by one to make it full proof.

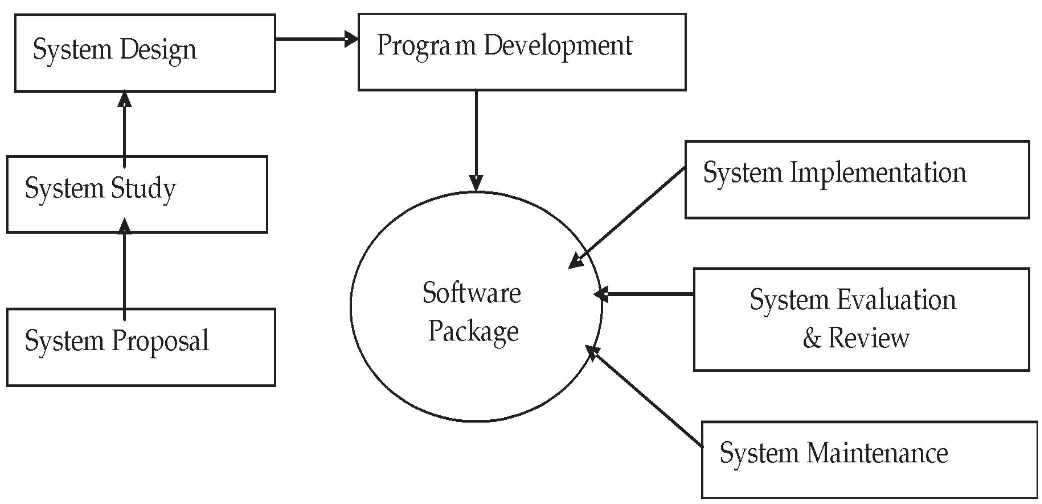
4.2 Development of Prototype

A prototype is smaller version of system in terms volume, complexity and cost. A prototype is developed as a pilot version to understand how the system will work and to assess what the things to be done to make the system successful and to visualize what benefits will be accrued. Implementation of actual system is a long term affairs. It helps to make decision making in giving signal for actual venturing into software development projects and what precautions are to be taken to make the project successful.

4.3 System Development Life Cycle

In fact system development involves seven stages as described below. These stages together is called System Development Life Cycle (SLDC). They are :

1. System Proposal
2. System Study
3. System Design
4. Program Development
5. System Implementation
6. System Evaluation & Review
7. System Maintenance



4.4 System Development Team

For a large system, following members are involved in the system development. Their task and responsibility are given below :

Step	Person Responsible	Responsibility
System Proposal	Systems Analyst	To study the requirement and prepare a proposal for clearance by the management.
Systems Study	Systems Analyst	Systems analysis of the existing system with Operation and MIS department employees and users and preparation of System Analysis report for clearance by User department and MIS department
System Design	Systems Analyst	Designing a system for checking by Project Manager / Systems Manager and develop systems specifications
Program Development	Programmers	To develop programs according to systems specification and testing the programs
Systems Implementation	Programmer & Systems Analyst	Implementation of the live data
System Evaluation & Review	MIS Manager &	To assess the performance of the system and suggest improvement
Systems Maintenance	Programmer	To take care problems / new changes in the systems
Documentation	Documentation Expert	To develop documents for users

4.5 System Proposal

In the System Proposal phase, the information requirement at different levels is assessed and the deficiencies and shortcomings in the existing system are studied to understand why it fails to deliver the desired information / reports to satisfy the requirements. With careful consideration of the operational procedure followed and changes required, a new system is proposed. For the above proposal, the following detailed activities are undertaken :

- Assessing enterprise's information requirement
- Identifying the shortcoming in the existing system
- Prepare a plan for system management
- Work out a Feasibility Report
- Cost-Benefit Analysis
- Prepare a report on overall system objective and plan of implementation etc

4.5.1 Feasibility Study : This is part and parcel of system proposal. This step is only to in-depth evaluate the details of processing involved and pros and cons of success factors for the proposed system. This step involves the consideration for the following :

- Size of scope of the project
- Systems Master Plan
- Risk involved etc

4.5.2 Analysis of existing system : The deficiencies in the existing system, need for possible improvement are studied and alternative sets of solution are devised. In this step, what is done is to see the existing system, their operational flow and the change in user's requirement in the evolution process of Information System.

4.5.3 Study the flow of Information : The flow of information from users are to be analyzed in order to strike a balance their action and their requirement. Analysis of I/O processing and its operational aspects is done at this stage. The improvement in the data flow is suggested at this stage for better reporting system.

4.5.4 Scope of Solution : The aim is to freeze the requirement of the desired system after the studying the following :

- Data to be processed
- Resources available
- Reports to be generated
- Time schedule to be maintained
- Reliability to be achieved
- Balancing the systems requirement and technical feasibility etc

4.5.5 Study of Technical feasibility

Technical feasibility means the consideration of the following technical factors of operation to match the systems requirement :

- Hardware configuration
- Capability of the software
- Network requirement
- Skill of operation staff
- Data security features in the system
- Control system

4.5.6 Study of Operation Feasibility: Operation feasibility means the fulfillment of requirement of generation of data at designed speed, maintenance of flow of data, adherence of criteria of satisfying the users, clients, employees, vendors etc. The issues which are studied are :

- Resistance to change
- Management support
- Investment requirement etc

4.5.7 Cost - Benefit Analysis: This is basically to justify the financial feasibility of a system. Before a new system is proposed, the benefits derived out of it should be weighted with the cost in it. Cost components which should be covered in the analysis are :

- Investment requirement in hardware procurement /rent
- Cost of software development
- Maintenance of hardware
- Cost of creation/conversion of data files
- Manpower cost
- Cost of computer stationery including floppies, tape etc
- Training cost
- Cost of maintenance of software
- Overhead cost – power, air-conditioning, rent etc

Financial and non-financial benefits from the system are assessed.

Tangible benefits :

- Decrease in data processing cost
- Saving through better information system

Intangible benefits : It is difficult to estimate them. They are like:

- Increased operational efficiency
- Good working environment
- Better information system etc.

Cost and benefits are weighted and observations are made accordingly for proper decision making.

Report on overall System Objectives and Implementation Plan. Generally System objectives outline the following :

- How the new system meets the changes in requirements
- Technological improvement envisaged
- Skill improvement plan for manpower

4.5.7 Implementation Plan *:* It indicates the benefits out of the system. Basic objective of this document is to plan the different activities and their time schedule :

- Investment Plan
- Software development schedule
- Personnel Resource Plan
- Managing the change
- Testing & implementation plan
- Training of the personnel etc.

4.6 System Study

This stage focuses on understanding the requirement of the system in terms of reports and their frequencies. What are studied the flow of information, requirement of hardware and software and logic/rules involved in processing of data at different stages. This step is also called System Analysis.

The details of analysis undertaken are as below :

- Analysis of the present system in terms of data flow, system logic and processing
- Understanding of shortcoming of the existing system in terms of speed of processing, flow of information and forms of reports
- Understanding requirement change in data and data flow to meet the new requirements
- Understanding of System logic
- Understanding of Reporting requirement, volume and frequency
- Assessment of Integration possibility
- Devising mechanism of system performance improvement

Methodology adopted for system study :

- Examining the present manual, data forms and output report
- Discussion with knowledgeable persons from MIS and User department
- Analysis of input and output
- Preparation of questions on doubts for clarification
- Consideration/ examination of responses of questions

4.7 System Design

Focus in this stage is to design the data structure, file (database), output. Specifications of the programs are developed in this stage to understand the inter-connections among different elements of different files (tables). In fact, System Study aims at understanding the whole physical system in an functional area (data, output etc) whereas System design aims at capturing the data in required specification so as to make the processing possible to generate desired output/reports.

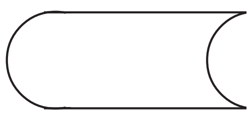
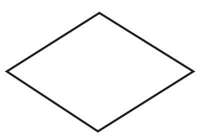
- Specification of data elements
- Specification of input form, records and files
- Specification of system input
- Development of system flow chart
- Development of program specification
- Determine file organisation & file layout
- Define reporting requirement, volume and frequency
- Development of operating specification

- Development of control & audit specification
- Designing the Output reports

Tools used in systems design

- System Flow chart
- Case Tools

4.7.1 Systems Flow Chart : It is a tool to present data flow and process steps in graphical diagrams. Each individual symbol used in the diagram represents a definite element in describing the total flow in the system.

Symbol	**Used to indicate**
	offline Activity
	Input document
	Data flow process flow
	Process step
	Data storage
	Decision box

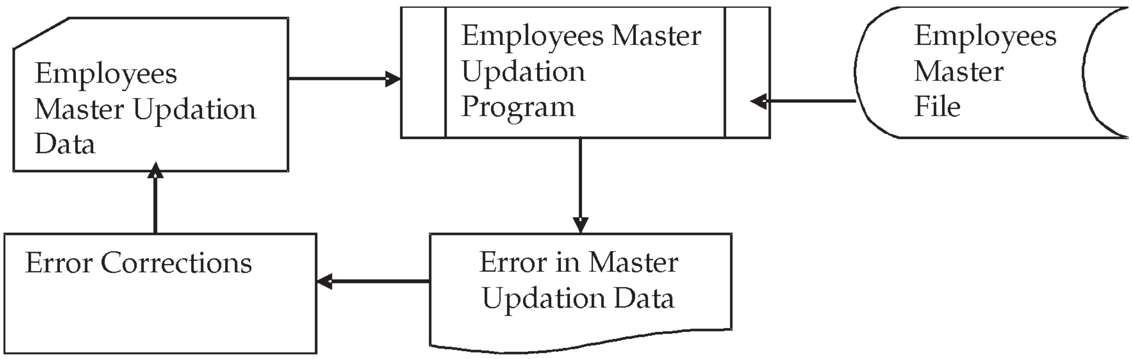
4.7.2 Case Tool : CASE (Computer Aided Software Engineering) : Case tools are used for having automatic designing assistance with the help of versatile system designing facilities available in them. They are used in the following activities :

- Drawing flow diagram
- Designing file structure
- Defining Data Dictionary

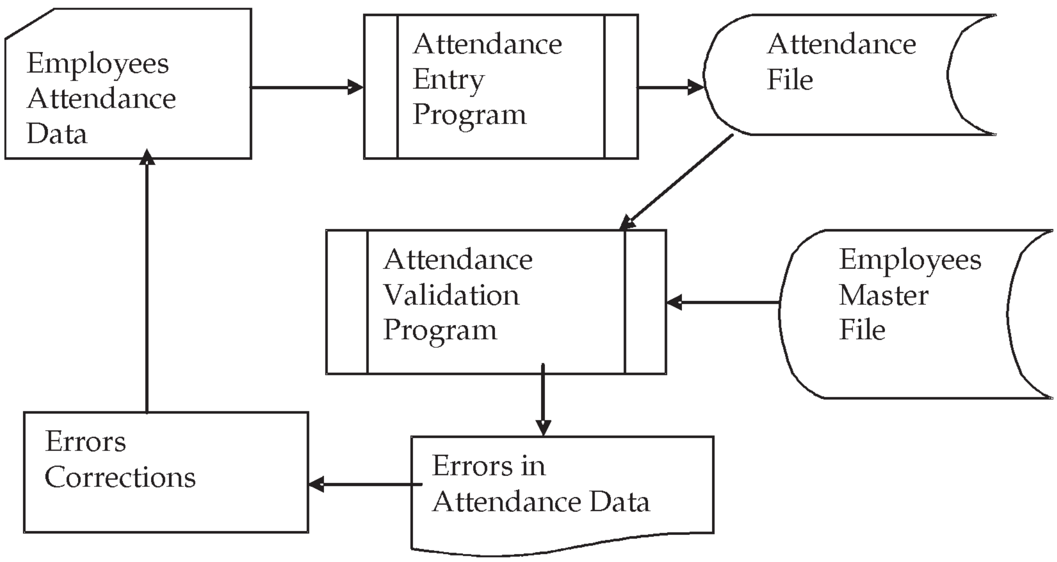
- Drawing forms
- Generating Report formats etc.

Example : System Flow Chart of Payroll (Batch Processing):

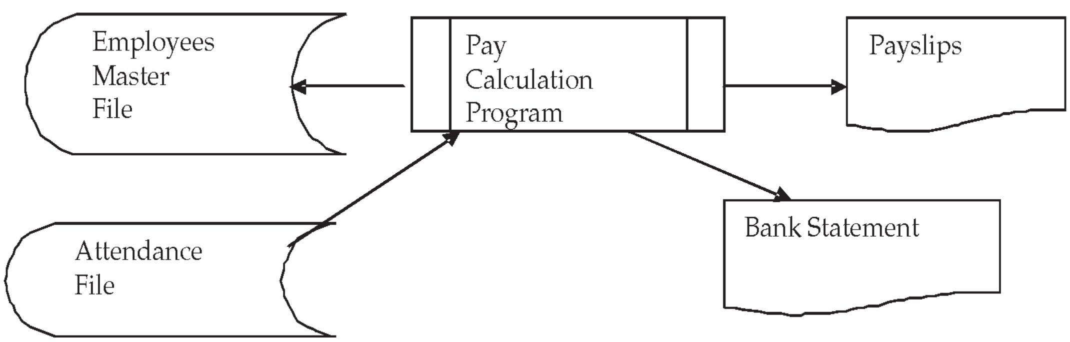
Step 1



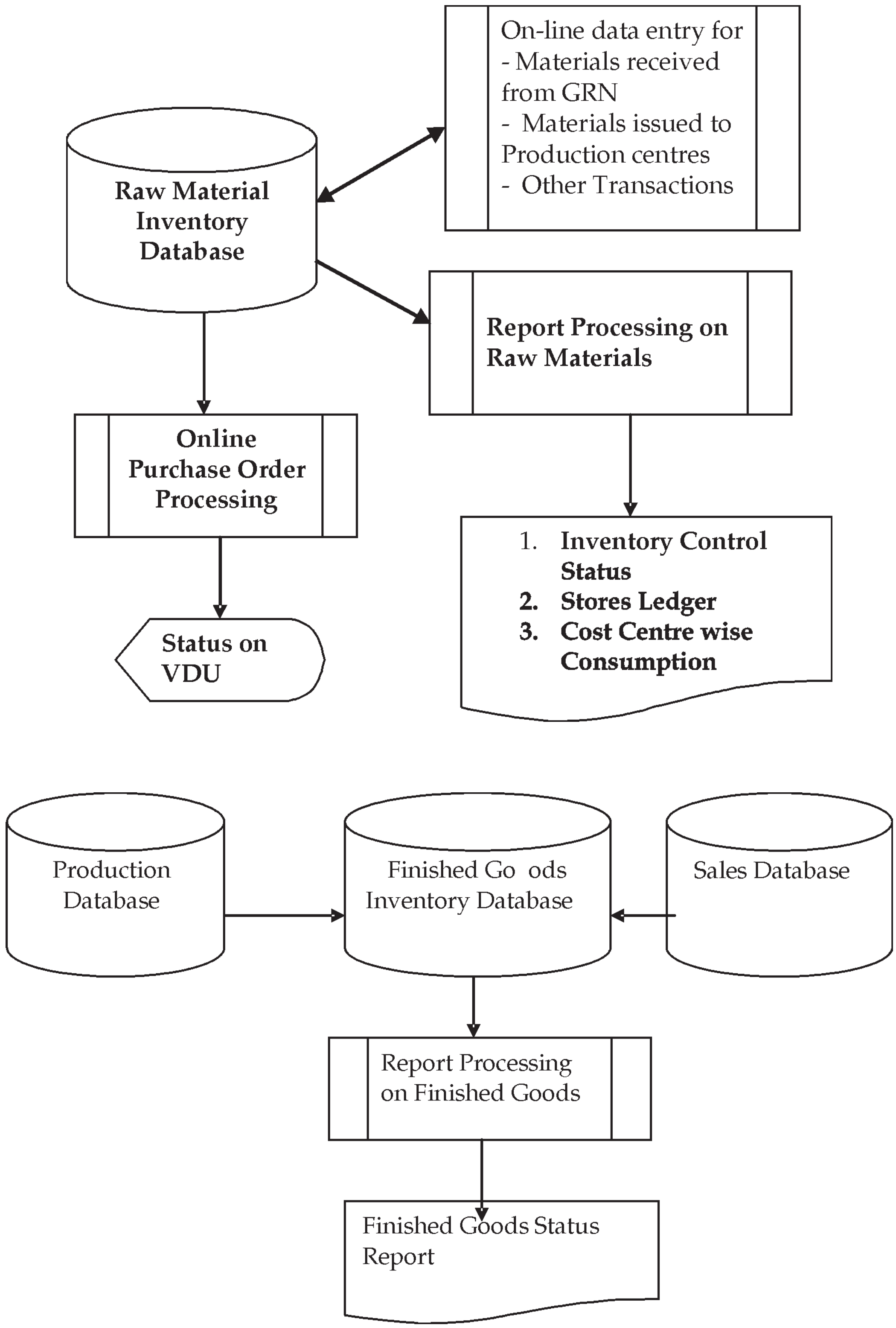
Step 2



Step 3



Example : Inventory Control System (On-line Processing):



4.7.3 Designing the Input : Input documentation based on proper input designing and required input flow for data for processing. Generally, input is prepared in a well designed form. The following points must be taken into consideration for designing input for data processing :

i) ***Contents*** **–** The data should fulfill the requirement of output reports.

ii) ***Format*** **-** The document should follow the natural sequence of data generation and the data size must be in conformity with the database design. Provision for separate box clearly labeled for separate item

iii) ***Timeliness*** **–** data must be prepared at right time to facilitate the schedule of data processing.

iv) ***Authentication*** **–** Input data must be authenticated by the authorised person.

v) ***Media*** **–** Creation of data file should be made on a media like floppy disk, tape or hard disk according to the design specification of the system.

vi) ***Volume*** **–** In case of huge volume of data, for data entry key-to-disk or key-to-tape system may be followed and the same may be processed in batch.

4.7.4 Codification of data : Codification is a system of convenient representation of data. Code is scientific representation of actual data in short form. Codification is adopted to represent long data by shorter name, to reduce the error in data entry, to classify the transactions easily and making data processing efficient.

For developing a scientific codification to take full advantage of it, the following points should be taken care :

i) ***Uniqueness :*** Unique code for each separate type of data item

ii) ***Convenience :*** Codes are generally comprised of numerical digits but alphabets may be used in the beginning to have more logical classification. Logic of codification should be simple and easy understandable by the users.

iii) ***Sub-grouping :*** Within the code, a group of characters are taken together as sub-code. This is to simplify codification and classification.

iv) ***Correction mechanism :*** Sometimes, check digit is also used to ensure accuracy in data entry.

v) ***Flexibility :*** Coding system should be flexible enough to ensure smooth incorporation of future modifications and accommodation of possible additional sub-groups due to changes in the system. In other words, future modification should not invalidate code structure.

Example : Employee Code helps to identify an employee easily. There is no need of entering his/her long name. Short Employee code serve the purpose. Similarly, the common codification are used for Accounts Code, Party Code, Item Code etc.

Accounts Code – for Accounts Heads in Accounting System

Party Code – for Party Name for Sundry Debtors, Sundry Creditors etc

Item Code – for item in Inventory Management System etc

Advantages of Codification :

- Shorter code in place of actual data reduces errors in data entry.
- Codes are used to classify the transactions easily

- Sorting or merging by code is a scientific system step in data processing. Without Code data processing will be cumbersome.
- Codification helps report generation to be efficient

4.7.5 Designing Source Documents: While designing source documents, the following points should be considered :

- Documents should be simple to understand
- Each document should have clear title.
- Each type of document should have a serial number.
- Different types of documents should be given different colour codes.
- Items of data should be put in the order of logically sequence.
- Layout of documents should be in standard size.
- One source document should be used once only to feed data.

4.7.6 Consideration in changing in existing source documents : The following precautions must be taken in changing the existing source documents for smooth change over :

- Changes should be kept as minimum as possible so that data preparation can continue without much hazards.
- Changes in new source documents should be limited to the requirements of the new system.
- Deficiencies of the existing source documents must be analyzed first and new documents should aim at fulfilling those.
- Data contents of the new source documents should be available at one place.
- Staff may be trained to equip them to efficiently handle the new source documents.

4.7.7 Designing the Output Reports : The following important factors must be taken into consideration for designing the output report :

i) ***Contents –*** set of information to satisfy the users of the report

ii) ***Format –*** to place the information in logical sequence to increase the readability and effectiveness of the report. In case of graphical presentation of the output, the selection of suitable format is important.

iii) ***Media –*** In earlier days all output reports used to be printed on paper for the users. Now with the advantage of on-line control, for example in banking services, or in case of real-time system like Railways reservation system many output requirements are on VDU. Thus, media of output reports has become an important consideration.

iv) ***Frequency –*** frequency of report depends on the need of the users.

v) ***Volume –*** Volume of report is a consideration. A voluminous report can not be on VDU.

vi) ***Usefulness -*** The purpose of the report may be for documentation (preservation of records), control information, interactive decision making etc. This aspect is considered for designing.

4.8 Program Development

Program development means writing programs according to program specification. This is also called coding.

The consideration for program writing are :

- Tools for developing program logic
- Programming Language
- Input design
- Files (tables) to be handled and their design
- Output / reports design

Program Development has the following steps to be followed sequentially :

i) Development of program logic with the tools

ii) Selection of Programming Language

iii) Writing the Program (Coding)

iv) Debugging the Program

v) Testing the Program with test data

vi) Implementation with live data

vii) Program Documentation

viii) Maintenance of the program

4.8.1 Tools for development of Program Logic : The tools available development of logic of the program are:

i) Decision Table ii) Flow Charts and iii) Algorithm.

Decision Table

It is a tabular representation of program logic showing the actions against the conditions. The components of a decision table are :

i) Condition Stabs - different condition entries in different rows (upper)

ii) Action Stabs - different action entries in different rows (lower)

iii) Rules - Rules are unique combinations of conditions i.e. combination of 'Y' and 'N' where 'Y' means 'yes' and 'N' means 'no' No of rules = 2 x Number of conditions

iv) Condition entries - under the rules, the combination of conditions are entered.

v) Action entries - Against the each condition entries, 'X' has to be entered corresponding to the action to indicate 'yes' according to the logic of the problem.

Example 1 : ABC Co extends special discount to its distributors who have business relation for more than 7 years or have business relation more than 3 years and volume of business is more than 10 lakhs. Draw the Decision Table.

Answer :

		Rules							
		1	2	3	4	5	6	7	8
CONDITION	C1 : more than 7 years business relation	Y	Y	Y	Y	N	N	N	N
	C2: More than 3 years Business relation	Y	Y	N	N	Y	Y	N	N
	C3: business volume More than 10 lakhs	Y	N	Y	N	Y	N	Y	N
ACTION	A1: Discount facility								
	A2: No Discount facility	X	X	X	X	X			
							X	X	X

Example 2: A manufacturer sells his products to three different types of customers with different discount rates based on order vales as :

Customer	Commission % on Order Value		
	Less than Rs 7500	Rs 7500 to less than Rs 15000	Rs 15000 and more
Retailer	5	8	10
Distributor	8	10	12.5
Govt. party	8	8	8

Draw the decision table.

Answer:

		Rules							
		1	2	3	4	5	6	7	8
CONDI-TION	C1 : Order < Rs 7500	Y	Y	N	N	N	N		
	C2 : Order > = Rs 7500 And < Rs 15000	N	N	Y	Y	N	N		
	C3 : Order - More than Rs 15000	N	N	N	N	Y	Y		
	C4 : Customer : Retailer	Y	N	Y	N	Y	N	N	
	C5 : Customer : Distributor	N	Y	N	Y	N	Y	N	
	C6 : Customer : Govt party	N	N	N	N	N	N	Y	
ACTION	A1 : Discount 5%	X							
	A2 : Discount 8%		X	X				X	
	A3 : Discount 10%				X	X			
	A4 : Discount 12.5 %						X		

4.8.2 Flow Chart: Flow Chart is the diagrammatic representation of the algorithm i.e. program logic. It uses a unique set of symbols to describe the conditions and actions.

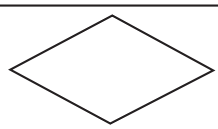
Technique of in drawing flow chart

- Starting with the input for main decision factor
- Putting the condition in the decision box
- Branching the condition into different path of decision box
- Branching should be done without ambiguity
- To remove ambiguity, more than one decision box may be used
- Writing the statements under each branch
- Avoiding crosses in the flow chart
- Using connectors to reduce the number of flow lines, if required.

Advantages of Flow Charts :

- Logical representation of problem steps
- Flow chart helps to make the complex logic simpler
- A visual aid in conceptualization of the problem
- It is tool for efficient programming
- Helps in debugging
- Support program documentation

Symbols used in flow chart

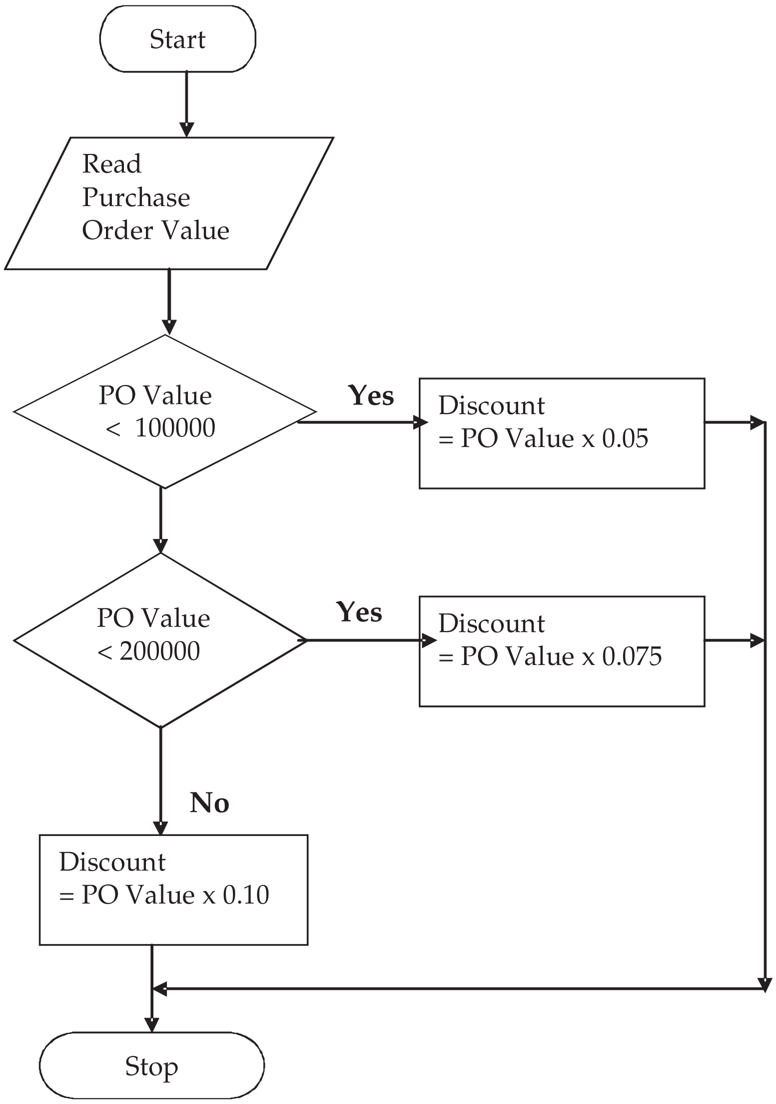
Symbol	**Used To Indicate**
	START / STOP
	INPUT / OUTPUT
	PROCESSING
	FLOW LINE
	DECISION BOX

Example 1 :

In a company A, discount on purchase is given on the basis of different slabs in the value of the order as given below :

Purchase value	Discount %
Below Rs 1,00,0000	5%
Rs 1,00,000 – 1,99,000	7.5 %
Rs 2,00,000 & above	10%

Flow chart for calculation of discount :



4.8.3 Algorithm : Algorithm is the logical steps of problem decision. A problem is divided into distinct logical conditions and actions under each conditions are framed. This is a tool for developing a program for a given problem.

Steps involved in developing algorithm :

- Understanding the problem
- Picking up the parameters involved in the problem
- Making combinations of parametric values to arrive at distinct logical sub-conditions without ambiguity
- Framing action path corresponding to each sub-condition
- Testing the algorithm with test data and checking the output

Advantages of Algorithm

- It helps the programmer to understand the problem thoroughly by breaking the logical conditions
- It brings solution step by step
- It is easy to debug the program with the help of algorithm
- It is independent of programming language

4.8.4 Program Life Cycle : Program Development follows the following seven stages :

4.8.4.1 Program Analysis – This is to understand the users requirement and logic of the business process to be taken into consideration. The programmer determines the requirement of the system in terms of input data handling, output reports generation and logic involved.

4.8.4.2 Program Design - In this step, the program is divided into different modules. For each module, algorithm and flow charts are developed to understand how program will work. A document is prepared which is called program specification. Programmer has to use the tools like file layout, input design, output report format and outlines of program logic. All these taken together form the program specification.

4.8.4.3 Program Coding : In this step, program is written. First, language of the program is selected and then coding of the program is done. The Programming language depends on the following criteria :

- Application area
- Data Structure
- Program logic complexity
- Skill of the programmer etc

4.8.4.4 Program Debugging *:* Debugging a program means eliminating errors in the program. Errors may be of two types - a) Syntax error and b) logical errors

Syntax errors *:* These are errors due to mistake in following the syntactical structure of the language in which the program is developed or there may be spelling mistake in the use of words and instruction codes. These errors are detected at the time of compilation with the help of a compiler. Unless the syntax errors are corrected, object program will not be generated.

Logical Errors : These are errors in program logic. These are generally detected at the time of execution or testing the program. Due to logical errors, program may fail to run or will generate wrong output report.

Compilation of Program – Once the free from error, the program has to be compiled with the help of compiler of the language chosen. This compiled program is run.

4.4.8.5 Program Testing : Program testing is part of system implementation. It is done with the help of test data to test the correctness of program logic in terms of data manipulation, file handling and output generation. This testing is done to make the actual implementation with live data simpler.

Test Data Preparation – Test data is to be prepared to check the correctness of the program.

The following excises are undertaken in this stage :

- Creation of realistic test data very similar to live data with proper boundary values
- Processing the test data with the help of new software
- Examining the correctness of the reports generated
- Verifying the status of updated files (table) to check correctness
- Identifying the errors and their causes
- Correction in the programs, wherever necessary etc

Debugging	**Testing**
Process of eliminating errors	Process of validating the logic of the program
It is after the program is written.	It is after debugging
It is done with help of compiler or interpreter.	It is done with test data.
It is done to eliminate syntax errors.	It is done to remove logical errors.

After the software is successfully tested with test data, the next step of effective way of testing the system is to make a parallel run of old and new software with the help of same set of live data. The results of both the system is compared to identify the variations. The parallel run must be completed with live data for a considerable period and all reports must be checked to ensure complete correctness of the system.

Difference Between Debugging and testing :

4.8.4.6 Program Documentation – Writing narrative details of the program. Documentation for program is known as **Programming Manual**. It gives logic of each program with the following details :

- Algorithm and flow-chart
- Program specification
- Source code
- Output report

4.8.4.7 Program Maintenance – This is required to accommodate the changes in the system. Proper documentation of all these changes must be maintained.

4.8.5 Quality of Program : Quality of program depends the following criteria :

- Accuracy - with no logical flaw.
- Reliability – giving consistent result.
- Readability – flow of logic is understandable
- Efficiency - Performance should remain good even with high volume of input data

- Maintainability – program with simple logical flow can easily be corrected by somebody other than its own developer.

4.8.6 Structured Programming

Structured programming means the art of developing programs in a structured fashion to make it readable and maintainable. The rules of structured programming are as follows :

A. Logical flow will have one entry and one exit.

B. Three basic structure :

   - Sequence of execution (DO)
   - If —— GOTO
   - If —— Then —— Else

C. No haphazard use of branching using GOTO

D. Top-down or bottom-up approach

4.9 System Implementation

At this stage, both hardware and software are put in operation. In the system implementation phase, the most critical task is the preparing work force. People resist change. Forceful voices (Union, employees, Supplier, Customer etc) are to be identified. They are to be made understand that there is no threat. Prospect, advantages and improvements are to be explained. Organizational readiness to accept the change is to be assessed.

4.9.1 Activities in System Implementation

- Adoption of new technology
- Procurement and installation of hardware
- Development of communication system
- Establishment of control measures
- Fault tolerant system development
- Development of procedure for system administration
- Loading the System in the machine
- Conversion of files
- Establish the new system of data flow and capture data
- Process data and verify the reports.
- Establish control procedures – both preventive and corrective
- Make provision for sufficient flexibility
- Training to operation staff

- Establishment of system of communication between operators and users
- Scheduling for report generation etc.

Conversion of files – transfer of all files, databases from the old system to new system. Normally file/ database design in the new system will differ from that of old one. To make things operational, the conversion is required.

4.9.2 Requirements for System Change Over: Change over means the switching over from one system to other. This becomes necessary along with change in environment and improvement in information system according to the requirement of development in management system. The change over involves a very great complexity in terms of up-gradation of hardware, software, skill requirement and operation. Following obviously requirement in terms changes in the system management are :

i) ***Conversion of files*** *:* New system will have change in the file design. Existing file must be converted in the new file structure in order to preserve the existing data and maintaining continuity of the processing. In case of newly design system, adoption database management system is in high proportion. The old data files in conventional file design need to converted in database.

ii) ***Skill improvement*** *:* Skill requirement for operation of the newly designed system is expected to be different. The users, system administrator, operator need to be trained to understand the change and technical matters involved in handling the new system. The thorough training on the new hardware and software features are essential for smooth running of the system. For example, if the new system is on DBMS the operating staff needs training on it, users need training to how to use it as on-line system and to have the information on interactive mode.

iii) ***Up-gradation of hardware*** *:* Old Computer Systems are to be replaced according to the requirement of the new system. If the new system is on net-working environment, the required hardware devices are to be arranged.

iv) ***Operation Scheduling :*** According to the requirement, the job allocation and responsibility has to be changed. The required security features in the data files and the system has to be established.

v) ***Conversion of the Software :*** Conversion of the software involves the testing the new software with the help of converted data-files (databases). The data-processing staff should be involved in processing thorough understanding of sequence of operation, security features, precautions to taken to prevent damages etc.

4.9.3 Different approaches for change over

1. ***Parallel Run*** – Both the old system and the new system are carried on till a point is reached when the new system is streamlined to take over the processing in its full form. This approach has the provision to have comparison in the reports, their correctness and desired efficiency in the new system.

2. ***Immediate change over -*** This approach favours the implementation of the new system straight way understanding the obvious problems in implementation. The approach gives more stress on solving the problems in the new system and taking care of the further requirements in continuous development process. This approach is adopted when there is a thorough change in the system and there is little scope in making a one to one comparison of the outputs of the old system and the new system.

3. ***Phase Wise Conversion -*** This approach is adopted only to avoid sudden load of full conversion process when the system is extensively widespread and are of broken in modules. Sometimes, this approach is adopted to avoid huge investment requirement in total change of hardware in one go. Another advantage in it is training of people in the new environment batch by batch with dislodging the whole old system at one point of time. This is a process of progressive changeover module by module and then testing of interconnectivity will be done in the last phase. This process is sometimes proves to safe and effective.

4.10 System Evaluation & Review

In the system evaluation phase, critical evaluation is made on whether the system performs in the expected level and targeted cost-benefit is achieved. The scope of improvement is also identified. The following exercises are undertaken in this stage :

- Review the users' initial feedback
- Evaluation of performance of system in terms of speed, reliability and timeliness of reports
- Storage and backup provisions
- Cost Benefit Analysis
- Evaluation of internal controls
- Evolving measures for continuous improvement etc

4.11 System Maintenance

System Maintenance is undertaken to take care of unforeseen errors in the programs or due to bug in the design. It also undertake continuous improvement in the system as envisaged in the Evaluation and Review stage. The activities in this stage are :

- To constantly watch the performance of the system
- To identify the points of modifications in the system to achieve higher efficiency
- To suggest better control mechanism to avoid risk
- To see the behaviour of the some programs in handling critical data sets
- To develop procedure for recovery from system failure
- To follow standard procedure for back-up of databases
- Standardisation of procedure of maintenance of hardware etc

Maintenance of Maintenance records is very essential to keep track of the maintenance work undertaken and to understand the performance of the system :

- Problems faced in the system and their frequency
- Quality of maintenance work
- Date of modification and nature of modification

4.12 System Documentation

System documentation is an important issue for the user. It provides detailed information of system to make users conversant on system with details of steps involved in the systems. It is an aid to users in respect of the following :

- Material for training
- A mean for implementation, maintenance and modification of system
- Guidance and operating instructions to users and operators

Contents of System Documentation

- Program description
- System description
- Data and file specification
- Input/output specification
- System error controls
- System test plan
- Program specification
- Program flow chart
- List of programs
- Control and audit trail
- Glossary & terms used.

Contents of Operation Manuals

- Program description
- Input/output specification
- Operating instruction of programs
- Provision of modification, up-dations and deletion of records in files/databases
- Program controls
- Output specification
- Precautions to be followed

Contents of User's manual

- Purpose of the system
- How to prepare source documents
- Design of input forms

- List of codes for various data fields
- Output specification
- Handling errors in source documents
- User's control over schedule of processing

4.13 System Development Controls

The following controls in essential during system development :

- Proper authorisation of document preparation for input data
- Documentation of Systems specification in System Manual
- Adherence of standard system of testing procedure
- Creation of password for authorised access at different levels of operation
- Development of system of maintenance of log book for system usage for recovery management in case of damage etc

4.14 Software Development Cost

- Manpower cost or consultancy fees for system study, design, development and implementation
- Cost of creation/conversion of files
- Opportunity cost of hardware/rent
- Cost of language software or data base
- Training cost
- Cost of electricity, stationery
- Other overhead costs etc

4.15 Operating Cost

- Cost of Manpower
- Cost of computer stationery – ribbons, floppy, magnetic tape etc
- Maintenance cost
- Insurance cost
- Cost of electricity
- Depreciation
- Other overhead cost etc

4.16 Readymade Software

Ready made software means an application package developed with the standard features. As it for application by wide range of customers, it is developed with adequate flexibility. Cost is comparatively low. Upgraded versions are available with more features at a low additional price.

Before selection of a ready made software, the following points must be taken into consideration :

- To what extent it satisfies the requirements
- To what extent the package can be modified to suit the requirement
- Input/output formats – whether they are acceptable
- Package constraints
- Control system
- Quality of documentation
- Training provisions
- Costs
- Maintenance provisions and costs
- Warranty period etc.

Implementation process in ready made software :

- Hardware procurement according to requirement of the software
- Codification and training of personnel and implementation are of standardised.
- There may be a need to change the physical application system according to the codification and the processing need of the system.

Advantages of Ready Made Software :

- Rapid Implementation
- Standard and established package covering a wide range of options
- Availability of standard manual
- Low risk of failure
- Training provision from vendor
- User-friendly
- Cost is low

Disadvantage of ready made software :

- Does not exactly satisfy the requirement of organisation
- No flexibility to accommodate any special features of system according to the need of the organisation

- The physical system and codification may be required to change to generate input documents according to the requirement of software .
- Hardware configuration according to requirement of software

4.17 Tailor made Software

Tailor made software means a software developed according to the need of a particular organisation. This can be done after following the total system development cycle for a system. The advantages are taking care of full requirement of the system with provision of change in future to accommodate new developments. The disadvantages are the long implementation time due to full software development cycle followed and the higher cost involvement.

Implementation process :

1. Following Software Development Cycle
2. Procurement of hardware devices needed

Training of the operating personnel and users.

Advantages and disadvantages of ready made software and tailor made software:

Ready made software	**Tailor made software**
Standard system	Systems according to the need of the organization
Generally user-friendly - easy to implement	System development process has to pass through SDLC. Naturally implementation time is longer.
Hardware must be according to the minimum configuration requirement of the software.	Software may be developed exactly to match the hardware configuration planned.
Systems requirement is pre-defined and rigid. It may require to bring change in physical system and data flow	The system will have enough flexibility to accommodate future changes
Training for operation of a standard system is easy. Training is significant as the list of do's and don't's are big.	Training for a non-standard is difficult. As the software is according to the existing physical system, adoptability will be higher.
Standard and comprehensive Manuals are supplied by the vendor.	Users manual has to be developed by the software development team.
Cost of software is low.	Development cost is high.

STUDY NOTE - 5

Data Management and Data Processing

5.1 File

In data processing environment, file organization plays a very important role. Depending on the type of application, procedure followed in the processing and the mode of processing followed for information generation, file structure is designed.

A file is a collection of records. A record is made up of related fields in a particular order. The various fields consist of group of characters. A character may be alphabetic, or numeric, alpha numeric or a special character.

A data field represents a specific data element. A record is designed according to the need of the information system and fields are arranged in an data file in some pre-defined order.

Example- Employee Data file in Payroll System contains records of employees. A record consists on different field giving different details of the employee concern. For example, a record of employee file contains the following fields:

	Field Name	**Field Description**	**Size**	**Type**
1.	EMPNO	Employee Number	5	A (Alpha Numeric)
2.	ENAME	Employee Name	30	A (Alpha Numeric)
3.	DT-BRTH	Date of birth	6	N (Numeric)
4.	DT-JOIN	Date of joining	6	N (Numeric)
5.	ESEX	Sex	1	A (Alpha Numeric)
6.	DESG	Designation	10	A (Alpha Numeric)
7.	BP	Basic Pay	4 + 2	N (Numeric)
	Etc			

Example - Actual data i.e. employee number for an employee is E0750. It is a alpha-numeric field.

5.2 Data Structure

Fixed length file – Record length is fixed.

Valuable length file – Record length is variable.

Key Field- A record is identified by its key field. This key field is used for searching a particular record for processing, display, editing etc.

5.3 Types of Files

5.3.1 Master File - Master file contains the information which are of a permanent in nature. In fact, in data processing environment, master files contain fixed information. These information are changed only by periodic updation, as and when the same is changed.

For example, an employee's master file contains the fixed information of employees. Normally basic pay, designation, department is fixed information. In case of promotion or transfer these information may change. In case of joining or retirement or resignation, file will be changed with additional record or deletion of record. Similarly, an accounts master file where the balances of accounts heads are maintained, gets changed due to periodic updation.

5.3.2 Transaction File*:-* Transaction files are the files in which transactions in a particular application are recorded. In payroll system, monthly attendance file is a transaction file where the records of attendances of employees during a particular month are entered. Similarly, for an inventory control system, all issues of stock items are entered from the issue notes during a particular period to create transaction file on issues.

5.3.3 Work File*:-* These are basically intermediate files created during processing for an application area. These work files are preserved for the sake of security or to keep provision for reprocessing in case of damage or loss of output file at a particular stage. When a system is designed, the designer specifies what work files are to be preserved for how long and the procedure to be followed to use work file in case of need of recovery.

5.4 File Organization

Organisation of a file is done with respect to the mode of access to a file is required during processing. Following are the types of File Organisation :

1. Sequential File
2. Random (Direct) File
3. Indexed Sequential File (ISAM)

5.4.1 Sequential File - Under this type of file organisation, records are placed one after another and the file can be accessed only sequentially one by another. The file may be sorted on the desired field to make data processing more effective and meaningful.

Advantage of sequential file :

i) Simple

ii) All machines and software have the provision to support sequential file.

iii) Easy and economic to create file

iv) Maintenance of back up is simple.

v) Easy to reconstruct

Disadvantage of sequential file :

i) Sorting required before processing.

ii) Whole file is to be processed even when activity rate is low.

iii) Same data field is stored in different data files creating data redundancy.

iv) File handling involves intricacy in logic.

5.4.2 Randon (Direct) File – Under this type of file organisation, data are stored sequentially on the value of the key field irrespective of order of creation of records. Provision of access to a record of having a particular key value is efficient. The access is not done sequentially rater direct. This is why, file organisation is called direct or random. The position of the record with a particular value of key field is obtained by arithmetic calculation. This helps to have direct access to the record.

Advantage of Random file :

i) Easy and fast access to the desired record makes processing efficient.

ii) Sorting of file is not required.

iii) File handing in data processing is simple.

iv) Updation of records is simpler.

v) It allows sequential access for processing.

vi) Most suitable for interactive and online applications.

Disadvantage of Random file :

i) Expensive hardware and software support are required.

ii) Storage space requirement is high.

iii) Addition and deletion of records in the file is difficult.

iv) Backup must be made with special security measures.

v) Programming logic is complex.

5.4.3 Indexed Sequential File – Under this type of organisation, records are kept sequentially and index is used to have faster access to the desired record. This means this type of organisation has the advantages of both sequential organisation and random organization. The index of key field maintain the logical record key and physical record key. For searching a record, this type of organisation follows a similar approach of searching a word from the dictionary.

Advantage of ISAM file :

i) File creation is simple.

ii) File access is moderately fast.

iii) File handling in data process is simple.

Disadvantages of ISAM file

i) Expensive hardware and software provision are required.

ii) Storage space requirement is high

Slow retrieval of records.

5.4.4 Comparison for dofferent file organisation

	Sequential	**Random**	**ISAM**
Access	Serial	Random / sequential	Random / sequentia
Possible media	Magnetic tape / disk	Magnetic disk	Magnetic disk
Normal uses	Transaction file Work file Master file	Master file	Master file
File design	Simple	Complex	Complex
Record length	Variable / fixed	Fixed	Fixed
Software cost	No special software cost	Special and high software cost	Special and high software cost
Updation of file	Slow	Fast	Fast
Back up	Easy	With proper security measures	With proper security measures

5.4.5 Criteria for File Organization:

File organization in a system depends on the following criteria:

i) ***File Activities*** **–** It indicates the number of successful attempts of having access to records in the files during the course of a process of operation. File activity in mathematical terms is a ratio as given under :

File activity = No. of records accessed / No of records in the file

If file activity is high, direct or ISAM file organization is better.

ii) ***File volatility*** **–** Volatility is the rate of change in the records in the file. Generally, volatility is considered for master file.

iii) ***File Size*** **–** large file handling is easy in sequential mode. In earlier days, when hardware cost was high, the preference was for sequential file. Now, the need of processing is considered to be most important.

iv) ***Back up*** **–** Back up provision for sequential file is easy . Back up of sequential file can be kept both in magnetic tape or hard disk.

v) ***Batch processing*** **–** Generally in case of batch processing, both master file and transaction files are created following sequential file organisation and processing is done at a particular point of time. The batch processing, file activity is high but file volatility is low.

vi) ***On-line processing*** **–** Generally on line processing involves high file activity and requires fast access provision to make processing faster. In that case, Random or ISAM organisation is suitable.

5.5 Data base

A data base of a collection of inter-related data with controlled redundancy to serve one or more applications in fulfilling their need. Database is used by an organisation to store its data from different operational areas so that they can be shared by each operation collectively. Use of database has become very popular over the conventional file system for two reasons - integrated information and its security features.

Characteristics of data base.

- ***Information Sharing*** – Data is shared by different applications
- ***Controlled redundancy*** - In a non-database system, each application has its own files. In a database, duplicate data is eliminated and thus redundancy is controlled.
- ***Consistency*** – Data set from database (i.e. from one place) ensures better reliability of data instead of collection of different files.
- ***Security*** – Unauthorised access to data base is restricted by use of password.
- ***Integrity*** – Data is kept in integrated fashion and updation at one place ensures high integrity
- ***Persistence*** – Data in the database exist permanently.
- ***Independence*** – The three levels in the schema (internal, conceptual and external) should be independent of each other so that the changes in one level does not affect the other.

5.6 Database Management System (DBMS)

DBMS means a specialized software to create and modify a database. A DBMS provides a mechanism of sharing and manipulating by properly authorized multiple users without compromising the security and integrity of data. DBMS can make several approach to manage the data.

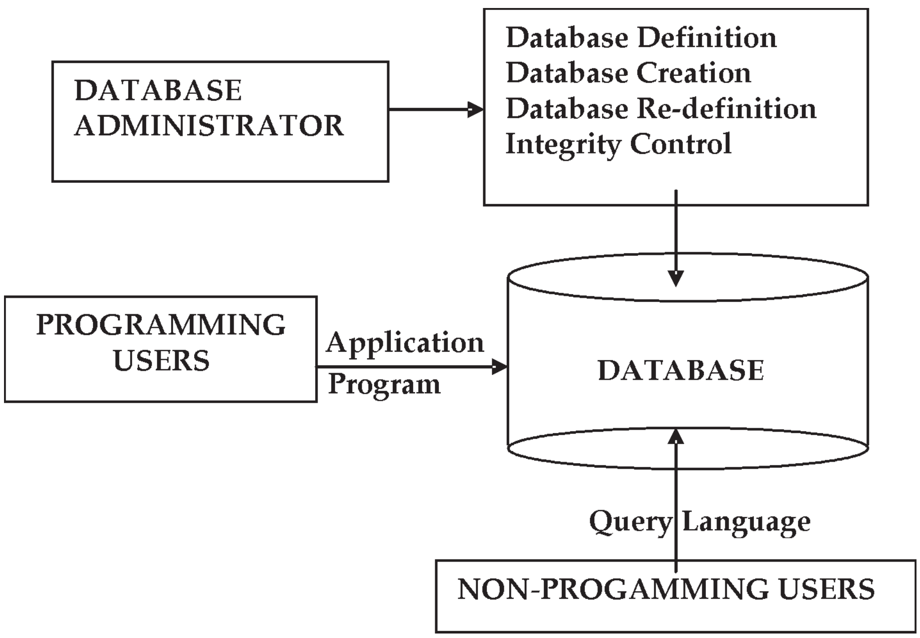
DBMS Offers the following services :

i) ***Data Definition*** – defining the data structure for storage of data

ii) ***Data Maintenance*** – Checking each records whether all information about one particular item. For example, to see whether in an employee table, all information about employee are there- like name, department, designation, salary etc

iii) Data Manipulation i.e.

- Insertion
- Updation
- Deletion
- Sorting



DBMS Software – A software supports the following :

- Data Definition Language'
- Data Manipulation Language
- Query Language
- Report Generator

Data Definition Language (DDL) – A language having sets of statements to define, maintain and a schema object.

Data Manipulation Language (DML) - A language having sets of statements to manipulate data in database. For example, insertion, deletion, updation of rows in a table and query on data from database.

DML compiler – It compiles DML statements into an application program.

Query Language - A language which enables an user to ask specific query to the database.

Report Generator – It enables the users to design and generate reports including graphical representation.

File Management – System of maintenance of data according to the design of the database.

Authorization to database Access – Database Administrator authorises different types of users different types of access to the database to control security of database.

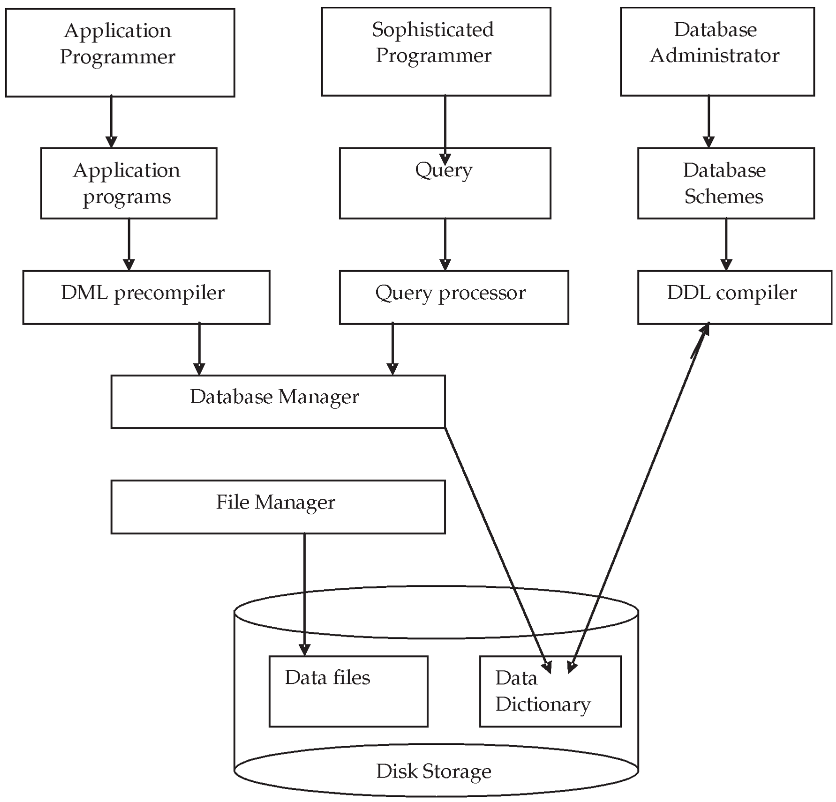
A Database Management System has different modules which takes care of different functions of a database. They are :

Module	**Function**
File Manager	Allocation of space on disk storage and store data structure
Database Manager	Interface between application programs and database
Query Processor	To Translate a query language to low level instructions to help processing of users requests
DML compiler	Conversion of DML statements into application program
DDL Compiler	Conversion of DDL statements into a table

Advantages of DBMS :

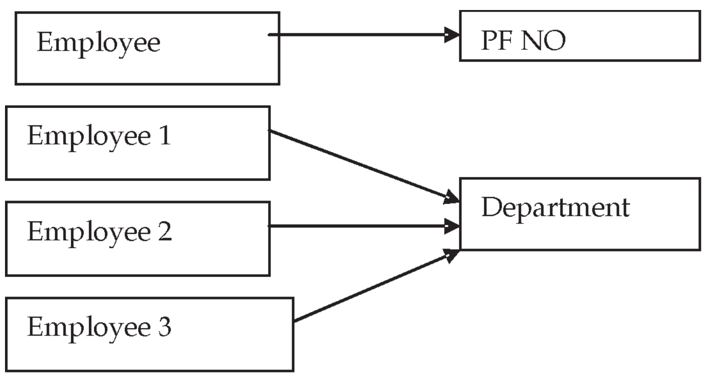
- Reduces data redundancy
- Ensures data consistency
- Provides check for data integrity
- Maintain in-built data security
- Offers flexibility to change data structure in case changed requirement
- Facilitates storage of structured information
- Provides concurrent access to multi-users.

5.7 DBMS System Structure

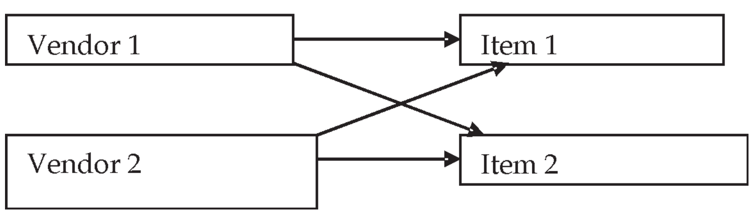


Relationship among data :

1. One-to-One
2. One to Many



3. Many to Many

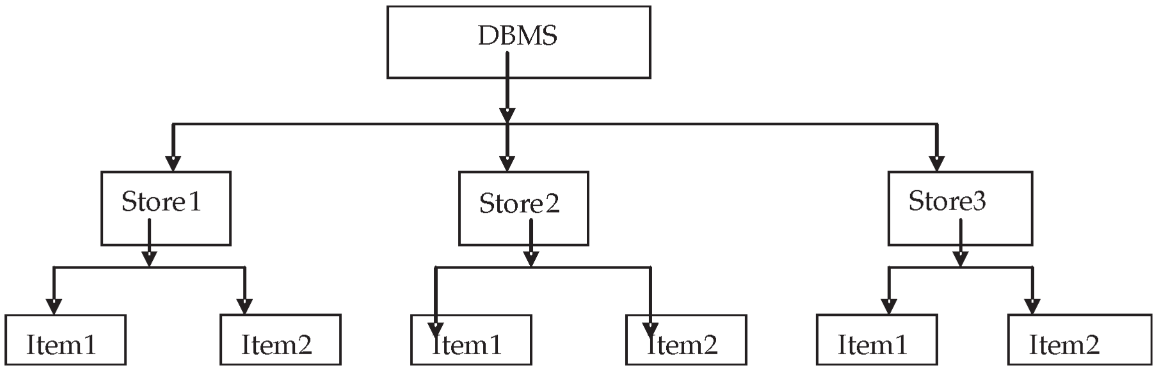


Different models of DBMS :

1. Hierarchical database
2. Network database
3. Relational database

5.7.1 Hierarchical Database:

The basic concept in the hierarchical database is that the data is organized on the basis of a chart of definite relation between different levels of data.



Main features of hierarchical database structure are:

i) Parent record will have some child records (all linked with it).

ii) A record becomes a child when it corresponds to its higher level record.

iii) The same record may be a parent record in relation to its lower level (child record).

iv) A 'child' has one parent but a parent may have many child.

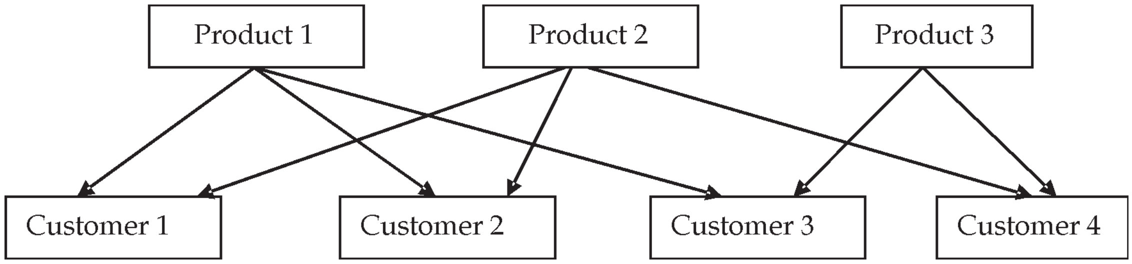
v) Between two consecutive levels of records, the relation is unique.

vi) It can not represent 'many to many' relationship.

5.7.2 Network Database:

In this type of database, each mode may have convection with many other modes showing the structure to be similar to be network. Nodes are connected in a multi-dimensional manner. When the relation among the modes are not as simple as in the hierarchical model. This model has many flexibilities and is suitable for a complex relation among the modes. The main advantage of this model is that the database can accommodate a number of inter-related records with relational path to be a network standard. The complexity of the structure is its problem to have wide acceptance.

The relationship is many to many. This is shown with the help of a diagram where three products are sold to different customers.



5.7.3 Relational Database (RDBMS):

Most widely used database model. Under this models, tables are formed with several closely related data elements and relation is established among the tables. No two rows in table can be identical. Relationship between two tables are established at column levels and the related data elements from two tables from different rows can be linked. The concept is very popular in the sense it is almost similar to conventional file system. The relational database software has a good provision for linking relationship among different tables and establishing security features for maintaining integrity of data.

Vendor Table

11	Company name	Company Address
V1	Vendor 1	Address of Vendor 1
V2	Vendor 2	Address of Vendor 2
V3	Vendor 3	Address of Vendor 3
V4	Vendor 4	Address of Vendor 4

Item Table

Item Code	Item Description
11	Item 1
12	Item 2
13	Item 3
14	Item 4

Purchase Order No.	Vendor No.	Item code	Item Qty	Purchase Order Value (Rs.)
P1	V1	I1	200	3000
P1	V2	I1	500	7500
P2	V2	I2	600	6000
P3	V4	I3	900	18000

Among the three above tables, relationship are established by Vendor No. and item code.

5.8 Normalisation

Normalisation is a process of organising data in a database. The fundamental principle of normalisation is that the same data should not be stores in more than one place. The basic aim of normalisation in data structure is to eliminate redundancy and inconsistent dependency. The design of database with greater level on normalisation provides better efficiency.

5.9 Code's Rules

Dr E F Codd first introduced relational database model in 1970. Codd's Rules are designed for stable structure for Relational Database. Rules are :

1. ***Information Rule*** **–** All information is explicitly and logically represented in tables as data values.
2. ***Guaranteed Access Rule*** **–** Every item of data must be logically addressable with the help of table name, primary key value and column name.
3. ***Systematic Treatment of Null Values Rule*** **–** RDBMS must support null values to represent missing or inappropriate information.
4. ***Database Description Rule*** **–** Description of database should follow the same logical structure with which the data are defined in RDBMS.
5. ***Comprehensive Data Sub Language Rule*** **–** The system must support the following :
   - Data Degfinition
   - View Definition
   - Data Manipulation
   - Integrity Constraints
   - Authorisation
   - Transaction management operation
6. ***View Updating Rule*** **–** All views that are theoretically updateable must be updateable by the system.
7. ***Insert and Update Rule*** **–** For all Insertion and updation, a single operand must hold good.
8. ***Physical Independence Rule*** **–** When any changes are made in storage, the application programs must remain unimpaired.
9. ***Logical Data Independence Rule*** **–** Changes in data should not affect user's ability to work with the data.
10. ***Integrity Independence Rule*** **-** Integrity constraints should be stored in the system catalog or in the database as a table.
11. ***Distribution Rule*** **–** The system must be able to access or manipulate the data that is distributed in other systems.
12. ***Non-subversion Rule*** **–** Integrity constraints defined by user must not be by-passed by RDBMS.

5.10 DATA PROCESSING

Data Processing – Data processing means conversion of raw data to meaningful information.

DATA → DATAPROCESSING → INFORMATION

Raw data means the data generated from application system. It is called raw as a single piece of data or some records on transaction do not provide sufficient means in decision making process. Data processing involves calculation or manipulation with those data in terms of sorting/merging, comparing and deducting a result whereby it makes some sense in the decision making process. In other way Data Processing can be defined as a process which generates output from some input in the

INPUT → DATAPROCESSING → OUTPUT

5.11 Data Processing Activities

5.11.1 Data Entry: Data entry generally means entering the transaction data from source documents either off line or on-line. Off-line means an environment where the validation of transaction data is not done with the help of corresponding master file and file is supposed to be created in the chronological order of the source documents. On-line means an environment where validity of existence of key records or logical correctness checking of other fields are being done.

5.11.2 Transaction file creation: This is done from the file created by data entry process with the following steps:

- Validation of data
- Checking and Editing
- Sorting/Merging on the keys required for processing

5.11.3 Sort & Merge : Sort and merge are two operations which are very common in data processing. Sorting means reorganizing the file in terms of sequence of a field or fields (sort keys) whereas merging means combining two or more files (having same specifications) on some fields. This is done with the help of a software which takes in an input file, specification of desired fields on sorting is required and name of the output file. If the input files are more than one and they are sorted on some fields to produce one output file, then it is merging the input files.

5.11.4 Updation: Updation means modifying the old information with current information – addition of records (insertion) – Deletion of records – modification of records. This is repaired when the information was incorrect and detected at the time of editing or otherwise. Another situation is very common when the information needs modification with the effect of normal business transaction. This updation may be on-line or batch mode. In a batch mode, updation takes place with the help of a transaction file. With the help of a program, the records are changed. Now a days with the change of technology, updation on on-line is being done to have instant result.

In a Railway Reservation system, updation is on-line. In case of reservation or cancellation of ticket, updation takes place immediately and output of ticket comes out instantly.

5.12 Factors For Decision On Mode Of Data Processing

The following are the factors to decide on the mode of data processing:

i) Volume of transactions and frequency of transactions

ii) ***Organizational structure*** – Organizational structure decides the points of sources of data, processing need, method of decision making etc

iii) ***Information requirement and its schedule*** – Process of decision making, type of data and impact of decisions on business process, control mechanism decides on information requirement, report structure and their frequencies etc.

iv) ***Computer system configuration*** – System of Computer configuration includes hardware configuration in terms of speed of processing and storage space, system software available in terms of operating system and language etc to determine the capability in order to select appropriate mode of processing.

v) ***Communication network requirement*** – Organisational structure and requirement of information communication or integration decides the type of network topology required to suit the decision making processing and information storage and management.

vi) ***Capability of software*** – The software capability is to judged to match the above requirements and to select appropriate data processing mode.

5.13 Advantage of Data Processing

The following are the main advantages of data processing :

1. ***Speed*****:** Speed of the data processing is the main advantage.

2. ***Volume of Job*** **:** A huge volume of data can be handled in data processing environment with ease.

3. ***Accuracy*** **:** Once software for an application area is tested and made error-free, accurate results can be ensured, irrespective of volume of transaction.

4. ***Reliability*****:** The computer is much more reliable than human being in the sense it does not have the fatigue to do the repetitive jobs.

5. ***Consistency*****:** In case of manual processing, the steps of calculation or approach may differ with the change of person responsible for the job and results may differ. In case of computer processing result will have steady consistency.

6. ***Timeliness*****:** Schedule for processing can be planned to adhere to timeliness of report generation.

7. ***Cost benefit*** **:** Data processing provides a great advantages in handling, processing and recording data in comparison to manual processing.

8. ***Data storage*** **:** A large volume of data can be conveniently stored in computer media.

9. ***Effective decision making*** **:** Because of timely and accurate information to Management, decision making becomes more effective.

10. **Intangible benefit :** Reports processed by data processing brings great image of the organization before the customers, industry and community .

5.14 Type of Data Processing

5.14.1 Batch Processing :

Batch processing means processing of a batch of data in one step. This is done only because the physical system generates data during a period of time which needs to be processed at one point of time. For example, data for payroll like attendance, advance, other non-standard deductions etc are taken into consideration for processing periodically i.e. either monthly or weekly. There is a cutoff date for accepting data and then they are batched (grouped) to process.

Batch processing has the following features:

i) Data is collected for a period of time (weekly, monthly, quarterly)

ii) The group of data are entered to create a batch file (transaction file)

iii) Check list is generated in order to identify the errors as validation of some of the important fields are not done doing entry in off-line mode

iv) Transaction file is edited and then sorted in required sequence.

v) With the batch transaction file and other related files, processing is done in one step.

Advantages of batch processing :

i) It is best suited when the application system generates the periodic transactions to be processed like in payroll or Financial Accounting.

ii) Time requirement of computer system is optimised. One computer can be used for many application systems if proper schedule for batch processing is done for different system.

iii) For large volume of transactions, this processing mode is cost-effective.

Disadvantages of batch processing :

i) Time lag : There is considerable time lag between data generation and report generation.

ii) Reporting System : Because of undue delay in report generation, information sometimes become ineffective for control measures.

5.14.2 Time – Sharing

Time sharing is a processing system by which numbers of jobs are processed simultaneously. This kind of system is adopted to utilise the CPU time more effectively. The cost of CPU is also high. CPU speed is much higher than I/O speed which in normal case results in idle CPU time. There are two different kinds of jobs. The one which takes more CPU time is called CPU bound job and other which takes more I/O time is called I/O bound job. Time sharing is a process of effective sharing of demand of CPU and I/O devices by the jobs but the scheduling of jobs by the operating system has to be very efficient. CPU bound jobs have to be assigned higher CPU times whereas I/O bound jobs have to be assigned higher I/O time during processing. CPU time is divided into small time slices and when one job is allocated some CPU time slices, other job is allocated the I/O time. When the second job finishes its I/O operation, the first operation is withdrawn from CPU work, either allocated I/O time or kept suspended for some time so that second job gets opportunity to finish CPU requirement. This is basically a technological development in evolving efficient scheduling of jobs and corresponding memory management needed for the jobs to be processed.

Advantage of Time-sharing

i) Effective utilisation of CPU time by reducing the idle time

ii) System of processing of multiple jobs simultaneously

iii) High response time

iv) A tool for real time processing

Disadvantage of Time-sharing

i) Problem of scheduling

ii) Problem of memory management

iii) Problem of data integrity and security

5.14.3 On-line Processing

On-line processing means processing of data in an environment where the terminals are attached to the Central Computer (i.e. terminals are on-line) so that the transactions are taken care of processing instantaneously. In on-line environment, the transactions may be processed finally afterwards in subsequent stage for generation of report but the validation of data is being done concurrently. For example, in Banks corresponding to each transaction of deposit or withdrawal the balance in the accounts is getting updated immediately.

5.14.4 Real – Time Processing: Real time-processing provide the facilities for immediate processing of transactions, updation of relevant master files or databases and fast response as far as output is concerned. Under this kind environment of processing, the output always shows the real-time position of an event and there is practically no gap in time frame between the incidence of an event and its impact in information production. For example, in Railways Reservation System the database in central location is getting updated instantaneously once the input for a reservation or cancellation is entered from any terminal under the railways reservation system and corresponding ticket is printed. Thus, the processing in Railways Reservation System is real-time processing. Similar is the case of Air-line Reservation system.

A real-time time system is necessarily a on-line system but the reverse is not true. This is because that in the on-line system, immediate processing is not mandatory and it is different from real-time processing whereas in real-time processing on-line system is a must otherwise the question of real-time processing does not arise.

5.14.5 Multi-programming: Multi-programming is processing a number of programs simultaneously by using the technique of time-sharing. At a given point of time, actually one job is executed and other jobs are allowed to do input/output activities. This is done for effective utilisation of CPU time.

5.14.6 Multiprocessing: Multi- processing involves simultaneous processing of more than one program by equal numbers of processors. It is different from the multiprogramming. In multiprogramming, one CPU processes a number of programs by time-sharing technique whereas in multiprocessing environment, the computer system is a multiprocessor one i.e. there are a number of CPU's in the system. When a job is put to the system for processing, it is allocated to a particular CPU with simple algorithm of scheduling and in the same way a number of jobs can be processed in the system. The sophistication required is in memory management. Large memory is required and memory partitioning for efficient data channelisation is required. With the reducing cost of micro-processors and job volume is too large, this system works very efficiently with less hazards. The cost of the main system is high.

5.14.7 Distributed Data Processing: Distributed data processing is essentially providing facilities to multiple users at multiple locations through network system under a multi-programming or multi-processing environment. This kind of system is adopted according to information requirement at different controlling points where transactions out of physical operations at individual points are fed into the system through the terminals. For example, this kind of processing is most suitable for an organization having sales office at multiple places and there is a requirement of controlling the operations of all centers from the Corporate Office. In such situation a large computer system at Corporate Office with many small processors at different regional offices and terminals at sales offices dispersed at different locations under communication network system can be termed as distributed data processing. In this system, data fed from different terminals will be processed instantaneously and feedback information is disseminated to all.

Advantages :

i) Reduction in delay in data processing

ii) Effective flow of information

iii) Good feedback information

iv) Support to efficient decision making process

v) Ability to share the data

vi) Direct user interaction facility

Disadvantages

i) Technical problem in connecting dissimilar machines

ii) Problem of data integrity and security

iii) Need of sophisticated communication support

iv) Maintenance problem may defeat the purpose

5.15 Information System Architecture

5.15.1 Centralized : In centralised data processing environment, data files are created on-line or off-line at different locations and processing takes place in a centrally located computer at the head office of the functional area. The basic objective of centralised processing are :

- Better control over data and processing
- Sharing of information from large data source
- Lower software and hardware
- Less hazards in operation
- Controlled security of data / information

5.15.2 Distributed Data Processing

In distributed environment, data feeding takes place at multiple locations simultaneously and processing is done according to the established procedure, normally instantaneously to reflect the business activities in the system on-line to make it truly real-time. For Distributed data processing, communication through internet is a must. The objectives of this type processing environment are :

- Cheaper hardware
- User-friendly hardware and software
- Instantaneous processing of information from different remote locations
- Privacy of data in stand alone mode
- Personal configuration of PC hardware and software

5.15.3 Client –Server architecture

In Client-server processing environment, there is a main machine (may be a main frame) which is called server (host) and which is connected with several terminals (clients) at different locations for the use by users. The server software accepts data fed from clients and returns the results to the clients. Network mechanism provides access permission to multiple users and allow sharing of peripheral devices. The most important point is taking care of transactions at multiple points on-line and facility of instant updation of database and facilitating the fast dissemination of information to clients users.

In Client Server architecture, the following are the main features :

- It is network based architecture
- Supported by good communication system
- Users are well dispersed
- GUI based operating system
- DBMS software is used
- Open–database connectivity driver (ODBC) and Application Programming Interfaces (APIs)

Advantages of Clients /Server Technology

- Permission of access to system to multiple users simultaneously
- GUI based operating system and GUI at client ends make operation user friendly
- Server and client may have different computer platforms – a flexible option
- Network capability provides good communication facility
- Network facility leads to effective utilisation of computer peripherals from number of clients on sharing basis
- Flexibility of up-gradation of system both at server end or client ends without much problem
- Management control improves through better information network
- It increases productivity of manpower in information system

It gives high and long term cost–benefit

STUDY NOTE - 6

Communication

6.1 Communication

Communication through Computers is transmission of signals generated out of data, massage, voice etc. These signals are in coded and decoded to make it meaningful between sender and the receiver. This understanding has lead to some rules which are called as protocol. The components involved in communication are :

- Hardware – all types of computer
- Software – that controls the transmission
- Communication Media – media through which electronic signal are transmitted
- Communication Network – link among the computers
- Protocol – Rules for transmission

The development of microcomputer has brought significant changes in communication technology. The low cost and flexibility of microcomputer has wide acceptability in communication system. The Communication software has been developed to have properly managed communication system with adequate security and integrity of data.

Methods of transmission may be parallel or serial.

Parallel Transmission uses different wires for transmission in different direction whereas serial transmission uses single wire to transmit each data bit continuously and serially.

Parallel Transmission	**Serial Transmission**
Use of different wires	Use of single wires
Hifg speed	Slow
Expensive	Low cost
Used for high volume data transmission	Unsed for transmission between a terminal and a computer

Codes are used to represent characters. Two main codes which are widely used in the world of communication are :

1. American Standard Code for Information Interchange -ASCII – 7 bit code represents 128 characters whereas ASCII –8 bit code represents 256 characters.
2. Extended Binary-Coded Decimal Interchange Code - EBCDIC – 8 bit code developed by IBM represents 256 characters.

6.2 Protocol

When two data communications equipments are connected together, they follow certain rules and conventions while transferring massages between them. Protocols are these procedure and rules for inter-computer communication. Protocols are software that perform a variety of actions necessary for data transmission between the computers.

In earlier days, there was not a standard set of protocol which posed a great problem in communication among different makes of hardware. The need for development of a standard protocol was felt. IBM developed System Network Architecture (SNA) which was for communication from mainframe to terminal. United States Department Of Defence (DOD) developed a model called Transmission Control Protocol/ Internet Protocol (TCP/IP) which has become a very standard protocol for network activities.

Protocol determines the following :

- Type of error checking
- Data Compression method
- Recognition of massage of sending device that it has finished sending a massage
- Recognition of massage of receiving device that it has received a massage

Some of the functions of communication protocol :

1. Control on information transfer
2. Specification on structure and format of data
3. Recovery steps in case of error
4. Re-transmission

6.3 Modes of data transmission over a channel

1. **Simplex -** uni-directional where feedback information is not required use simplex communication. Example - Radio, Television
2. **Half-duplex –** both directional but either sending or receiving at a time. Example - Internet surfing
3. **Full-duplex -** data can travel both directions at a time. Example -Telephone system

Asynchronous communication is transmission between sender and receiver having independent clocks i.e. any transmission between devices of dissimilar speed like connectivity between computer and printer.

Synchronous communication is Transmission having synchronization between the clocks of sender and receiver. For example, communication between computer and telephony network.

Characteristics of asynchronous Communication	Characteristics of synchronous Communication
• Simple interface • Inexpensive • Limited speed – less than 64 kbps • Requires start and stop bits • Parity bits often used to validate correct reception	• Complex interface • High speed data transfer

Terminal : Strictly speaking, terminal is referred to device having a monitor and a key board and connected to a server. If the terminal is having CPU, it is called intelligent terminal. In fact, terminals are the clients of the server.

Modem : Modem coverts the digital signal to analog signal and they are carried to the circuit designed for analog traffic. Modems are used in pairs. At receiving point, it receives the analog signals to convert them into digital ones which are sent to the computer. A typical modem speed range from 14000 to 56000 bps.

Multiplexer : A multiplexer is a electronic device which carries multiple signals on a single carrier at a time. Multiplexer combines transmission from several computers, transmit the same simultaneously and at the end of the channel with another multiplexer separates them. Use of multiplexer has made the communication very cost efficient.

Node : A device on a network. Example – Client, server, hub, modem, gateway, etc. In network, nodes are of two types – end nodes and intermediates. For example, in Telephone network the handsets are end notes whereas exchange switches are immediate nodes. In computer network, the computers are end nodes. The end nodes do not normally take part in deciding the route of data transmission rather it is decided by the intermediate nodes.

Route : It is the path between to nodes.

Communication Media : Network media linking the nodes. Example : Network Interface Card (NIC) or Cable or modem, hub, bridges, routers etc.

Repeater : Repeater is used to regenerate the signals to their original strength. While traveling long distance, signals become weak. Repeaters take care of this problem to ensure correct and safe transmission.

Bridge : It is a device within the network to smoothen the transmission by taking care of the load of network by way of a mechanism of segmenting the network and directing the packets accordingly.

Router : It a inter-network device which is used to extend or segment network to connect nodes across the network. Router decides the path of the packet. Routers are hardware and independent of topology of network.

Brouter – It is network device having capability of both bridge and router.

Bandwidth : It is the rate of data transmitted unit of time in a communication media. Example – kilobits per sec (kbps) or megabits per sec (mbps).

Circuit switching : Circuit dedicated for transmission. Example – Telephone Exchange.

Packet switching : Under it the massage is split into three parts. Header contains information on data in the packet. Body is the actual data. Footer holds information of error, if any.

One of the fundamental concept in data communication is to understand the difference between analog and digital signal. An analog signal is one which is continuous whereas digital signal may take on discrete values which are in binary form. Frequency in analog signal is measured in Herz (Hz).

Transmission of analog signal over a distance requires use of signal amplifier which boost the power of signal. Digital Signal transmission uses devices known as repeater. Digital transmission of data is less prone to error than analog transmission. Other advantages of digital transmission of data :

1. Cost : Due to development of microprocessor and VSLI technology, cost of digital devices are less than analog devices.

2. Data integrity : Data integrity is higher in digital transmission
3. Multiplexing analog signals require expensive communication devices whereas multiplexing of several digital signals on communication channel can be done with low cost machine.

Mode of Communication

Different transmission media are given below :

Telephone line (twisted pair) : The telephone lines are insulated conductors twisted together for the purpose of minimizing noise from environment and referred as twisted pair. It is cheap and widely available for installation. It radiates good amount of energy and susceptible to outside noise.

Co-axial Cable : It consists of a central conductor surrounded by insulating inertia. Co-axial cable has a relatively high frequency response due to its low capacitance and has good noise immunity. It is use in under-sea telephone lines. Its high cost may prove to be a disadvantage in its use in certain installation. Data transmission over a co-axial cable is divided into two type:

Baseband – for analog transmission

Broadband – for digital transmission

Microwave : Microwave transmission consists of high frequency radio transmission. It is generally used for high volume data transmission and point-to-point communication. It is used in wide brand communication system and is quite common in telephone system. Television system also utilizes the microwave transmission. Microwave towers can not be placed more than 30 miles apart. To minimize line-of-sight problem, microwave antennas are used.

Fibre optics : Fibre-optic technology is used to transmit the signal using glass fibre. It radiates light rather than electricity. It is made of glass and plastic and the cladding part has a different refractive index from the core which minimizes the light loss through the sides of the cable and promotes internal reflections down the length of the core. It is very good transmission media in terms of speed and capacity and less hazards. Fibre-optic cables has made great contribution in reduction of communication media in terms of size and weight but enhanced the speed of communication. A single glass fibre can carry more than 50,000 telephone calls simultaneously compared to 5,500 calls on a standard coaxial cable line. Speed of optical fibre in laboratory is six trillion bits per sec.

Satellite Communication : It has some unique features which are given below :

- It has very high capacity
- Transmission is cost independent
- It has a capacity to broadcast transmission over a wide geographical area.

Cellular Radio Technology : A Radio transceiver and a computerized cell–site controller controls all cell-site functions. All cell-sites are connected to a mobile telephone switching office that provides the connection from cellular system to a wired telephone network. As a user travels out from one cell serving area to another, switching office transfer the calls from one cell to another.

Communication for Information System

The range of communication media available is wide. The Information system select the proper communication system so that collection of information is efficient and cost effective and according to the need of the management for business decision making.

Computer Network

With the revolution in the internet technology and its growing popularity has brought the word 'network' ' in common use. A network may be defined as a set of interconnected operation. According to webstar' Dictionary it is defined as " The act or process of informally sharing information and support, especially among members of a professional group.

In today's revolution in computer technology, a very significant role is being played by the networking facilities among the computers. The concept of distributed data processing is gaining momentum in the world of business information system. The prospect of linking business units of purchase, production and sales channels through network has been envisaged by the scholars of business information system. The old model of a big computer serving the need of all functional areas has become outdated. The biggest advantage the network is sharing information and resources by multi-users.

Operating environment in business world has changed. Railways Reservation System or Airlines Reservation System has changed the outlook in business world in India. A Bank is giving us balance immediately on the terminal, passbook is updated on the printer within few seconds. These all are the boons from Computer networking system.

Computer network is a system by which computers at different locations can be linked to each other so as to make them enable to communicate among themselves. The ability to communicate is a facility. The advantage factor lies in sharing the resources and avoiding duplication of work and facilities of compilation of information from various locations efficiently. The objectives of Computer network are:

- Sharing resource like databases, software, equipments etc
- Saving Cost of hardware and software by sharing them effectively with client- sever technology
- Highly effective information system in a distributed data processing environment
- High reliability in information transmission

Network Administrator – He is responsible for maintenance of a network.

Network Software :

Network Operating system is a software that controls the hardware devices, software, communication media and channels. Two popular network operating systems are Novel Network and Windows NT Server.

Novel Network : The most popular software in network is Novel Network. It is based on client-server model. Under this system, a powerful PC should be a server.

Windows NT Server : It is Microsoft's advanced operating system for networking environment. It has a built-in security features. Some features of Windows NT are :

- Data are transferred in 32 bit blocks
- Windows NT gets access to full memory of the system
- Mutli-threading Operating system thereby allowing more than one process to execute at the same time.

Network Architecture

The term network architecture refers to either hardware, software or a combination of both hardware and software. The architecture determines the how the network will function. Network architecture may be broadly classified as either peer-to-peer or client /server architecture.

Information system architecture

Peer-to-peer architecture

Under this type of architecture, each workstation has equivalent capabilities and responsibilities. There is no computer at the centre connecting others through it. It is simpler and less expensive but under heavy load condition their performance is good. Individual resources such as disk drives, CD-ROM drives, printers become shared resources which can be accessed by any node. The benefits of peer-to-peer architecture are:

- No Network Administrator is needed
- Network is simple and easy to maintain
- Each computer can provide back up copies of its files to others for security.
- Cost of network is low.

Centralized Architecture

Under this kind of architecture, a single central processor-mainframe or mini computer is located at a central location and the processing is being done there. Workstations are placed at different locations for feeding transaction data from there itself. These workstations can avail the feedback information after processing at central computer. Client/ server architecture which is widely being used to-day follows the same concept of information management.

Client/Server Architecture

Under this type of architecture, at the centre there is a powerful computer dedicated to managing the disk drives, printers and network traffic management. Less powerful computers (workstations) are clients which depend on the server for their access to ant data or resources from the server.

Server - The server is the main Computer in a network environment holding data and other resources (software, hardware peripherals etc.) in a centralized way for enabling the clients to share them. It is basically high performing computer taking care of network management, security based access control etc.

Client - Client in a networking environment is a workstation through which the users have access to the data and resources of Server. Server provides the services of information sharing to the clients.

Open systems and Enterprise Networking

Open system means seamless connection of any computing devices, regardless of size and operating system. Hardware connected may range from PC laptop to mainframe. This system represents great flexibility in communication architecture. This kind of network is a dream goal in technological development. This kind of systems are very limited in numbers. The Open system needs connectivity across various components. Connectivity means ability to exchange application and data from one system to the other. In many enterprise now several LANs are seen to be connected with a WAN. This kind of network can be called an enterprise network.

Network Topology

It refers to the organization of a network. Nodes in a network are the data processing equipments. Channels are the connections among the nodes. These channels may be physical or logical. Physical connections will have continuity whereas logical connections will not.

Star : In Star topology, terminals (end nodes) are connected to a central node or hub node. The features of this kind of topology are :

- performance of this kind of topology depends much dep[ends on the processing power of the central hub
- Terminals have very little active role in network processing and less processing overhead
- Failure of central hub makes the whole system down
- It has the flexibility to accommodate any additional terminals.

Bus : In bus topology, a single network cable runs within a specified area and the terminals (end nodes) are connected to it. The following are the features :

- Bus network is usually limited to a distance
- There is a need of a routing protocol to manage all the terminals which share the common bus.
- Flexibility provision is there to add any terminal.

Ring : In ring topology, one node is connected to the next and next to the next and last to the first making a shape of a ring. Features :

- There is a direct point-to-point connection between two neighbouring nodes
- Transmission between the two placed apart has to be done through the intermediate nodes, causing extra overhead of network processing for the others.
- It has also the flexibility of addition of terminals.

Tree : Tree topology is, in fact, a combination of BUS topologies. Several bus LANs are joined to a main bus through repeaters and bridges to form a structure of tree. Small BUS based LANs are like branches. Features are :

- Each node is identified by its unique address.
- It needs routing protocol to ensure correct data transmission to a target node
- The structure is a complex one but provides unique feature to integrate several existing LANs in different functional areas.

Local Area Network (LAN)

This kind of network is an inter-connection of computing equipments over a localized area. The geographical boundary will be within 5 km. and data transfer rate is as high as 1 mbps to 30 mbps. LAN generally uses an assorted topology.

Salient features of LAN :

- Computing equipment are spread over small geographical area.

- Communication channels between the machines are private
- Server is powerful microcomputer or minicomputer or mainframe.
- LAN file server is a repository of variety of software and data file for the network
- Relatively high capacity communication channels are used
- More reliable in communication
- Cost of interfacing is usually low
- Each device in LAN can work independent of network.

Selecting a LAN

There are several factors that must be taken into considerations for selection of LAN configuration and the corresponding control features. The following are the important factors :

- Work load – allowable delay under tight condition and controlled delay in heavy load condition
- A baseband BUS topology is simpler to install and maintain. Bus network becomes more reliable with the use of passive taps. Down time is less.
- In a ring topology, the transmitted signal is regenerated at each node thereby minimizes the transmission error and enhances the safe distance coverage area. The acceptability of optical fibre technology in ring network provides high performance possibility

PC bound LAN

One high performance PC is put as file server. Novel Netware software can run on wide varieties of hardware. File server allows the access to all files on the local disk or shared disk storage. The main features of such LAN are :

- Security features allows the network supervisor to grant user authorization and access right
- Files may be sharable, non-sharable, read only, with read/write permission

Wide Area Network (WAN)

This kind of network is an inter-connection of computing equipments over a wide geographical area. It uses low capacity data transmission technology (nearly 1 mbps).

Salient features of WAN :.

- Computing equipment are spread over wide geographical area.
- Communication channels between the machines are from third party like telephone company, satellite channels etc.
- Relatively low capacity communication channels are used.
- Reliability in communication is not fully guaranteed.

Hardware Connection

1. Each node is connected to main physical medium through a transceiver unit, also known as medium access control (MAC). (max distance of 50 meter)

2. Transceiver is attached to the cable with two clamps
3. Ethernet cable is extended with repeaters to improve performance
4. An Ethernet host interface connects the transceiver and controls the operation of transceiver.
5. Transceiver unit is connected to the host unit with five sets of wires:
   - carrying power to transceiver
   - sending data
   - receiving data
   - allowing signal a collision to the next interface
   - for host interface to initiate isolation of transmit path from the cable
6. The interface accepts the basic data transfer instructions from the computer, controls the transceiver to carry them out, interrupt when the task is over.

Net work Management

The network management involves management of the following :

- Optimal use of resources
- Monitor the configuration of hardware and software continuously
- Right monitoring the performance of network
- Preventive maintenance and fault management
- Security management

Security Management in Network

Security of information is the most important issue in communication network. In the age of Internet technology, security management in network has gained a serious dimension and there has been good development in this area.

This is best managed by controlling the access to the system. Access to the system is controlled by password issued to different categories of authorization level of the users.

Firewall

Firewalls offer an effective system to protect access by unauthorized user from outside. The main feature of firewall is packet-filtering router so that vital information does not pass to any unauthorized intruder, even if he manages get access to the network system. It is a system of security in the network with the help of hardware and software. A software checks all incoming and outgoing internet traffics. The firewall routes the massages to a safe area to avoid any danger in the in forward transmission of massages. The screening by firewall software may delay the transmission process but ensures proper security.

Limitations of Firewall

- Passing on information by internal employees through internet can not be checked
- Firewall can not protect the system from virus

Cryptography

Cryptography is a technique to encrypt and decrypting massages for maintaining confidentiality in the information between sender and receiver.

Encryption

Encryption is a process of converting a text into a scrambled form by the use of some mathematical function. Decryption is the reverse process to convert the scrambled form of text into readable text. Generally, there two functions – one is used for encryption and the other one is for decryption .

Internet

Technically internet represents international network, that means a network connecting the whole world. Internet can also be said as network of networks. These interconnected network exchange information seamlessly. The power of internet rests on open architecture. Internet has grown to thousands of regional networks connecting millions of users. They are connected with high-speed long-distance back-bone network with standard protocol.

The biggest achievement of internet technology is that the contents of file is directly displayed instead of his downloading the file onto his computers.

Internet is a great invention of this age. It has changed the map of communication. The use of internet in normal business communication has gone beyond all estimates and changed the total scenario in the world of communication. As the world is being developed into a global village, integrated voice and data technology is being viewed as a vehicle that will bring about the transformation. Internet is an undeniable example of technology enabling commerce.

The usage of internet has increased boundlessly over the years. In 1998, the users were less than 2% of world population. In 2001, it was estimated that approximately 500 million people were internet users. The internet is the massive electronic communication network among the businesses, consumers, government agencies and common people over the world.

Internet usage in 2001

Country	As percentage of population	No. of users (millions)
United States	49	134.6
Sweden	49	4.4
South Korea	41	19.0
Australia	40	7.6
Canada	38	11.4
Netherland	35	5.5
Taiwan	32	7.0
United Kingdom	28	16.8
Japan	27	33.9
Germany	24	19.9
Italy	22	12.5
France	15	9.0
Spain	14	5.6
Russia	5	7.5
China	2	22.5

Evolution of Internet Technology

1. In1950, the Computer scientists developed technologies that the computers can be linked to each other and share data, known as networking which opened a new vista in computer data processing.
2. In 1969, US Government established a network among four computers for its defense research and the network was named as ARPANET (Advanced Research Project Agency Network).
3. In 1970, the network was extended to academic institutions. In 1983, ARPANET was transferred to National Science Foundation (NSF) exclusive for research and education and a separate network named MILNET was put on operation for Defense Research.
4. The APRANET developers felt the need of a mechanism for 'people-to-people' communication system. The outcome of which came in 1972 in the form of Electronic Mail (E-mail).
5. E-mail has played a pivotal role in the development of internet protocols and internet engineering
6. The important software TELnet & FTP were developed. Telnet is for having access to host computer irrespective of location and FTP (File Tranfer Protocol) for transferring files between two computers.
7. TCP/IP (Transmission Control Protocol/Internet Protocol) was developed as a universally accepted standard protocol for internet communication.
8. NSF (National Science Foundation) developed a NSFNET connecting five super computers using TCP/IP technology for the use of universities and research community in USA. Subsequently, NSF encouraged Canadian and European Universities to join NSFNET.
9. In 1984, DSN (Domain Name System) was developed to facilitate the users to navigate with the help of Domain name. The removed the problem of remembering the internet protocol address of ten digits (IP numbers).
10. By 1985, internet became an established technology.

Function of Internet

Internet has brought revolutionary change in communication technology throughout the world. The future of this development is beyond the normal imagination. Functions of internet, as on today's technology, are given below :

- Open communication throughout the world through worldwide web services
- Interpersonal communication through e-mail

Internet Connection

For an access to an internet, following facilities are required in the computer :

1. An Account with internet Service provider – Internet address
2. A telephone connection / Cable connection
3. A modem (Internal or external)
4. An internet browser software (Internet Explorer/ Netscape Navigator etc.)

Factors for high popularity of internet :

- Instant communication facilities has resulted phenomenal growth in business efficiency
- Phenomenal reduction in communication cost
- The cost of hardware and technology is within the reach of small entrepreneurs
- Display of information about an organization, its activity and product through websites has become a common mode of advertisement
- Accelerating dissemination of knowledge and information
- Prospect of E-commerce
- The commercial success of Business Process Outsourcing
- A facilitating media for recruitment etc.

Problems in Internet

While application of internet has opened up marvelous communication facilities in business environment, research and development and at personal level, the problems associated with it are as follows :

1. ***Security Problem*** **–** Internet hackers reveals the password of an user and get unauthorized access to his confidential and sensitive information causing serious damage.
2. ***Legal Problem*** **–** Question on legal validity of documents transferred through internet communication is a serious one. When communication is beyond formal one where contractual obligation and other legal issues are involved, the problem may pose to be of serious dimension. For example, e-Commerce.
3. ***Technological Problem*** **–** Technological problems are of two kinds. Lack of standardization in communication mode in terms of file type and support software creates problems in effective communication. The other problem is relating to excessive burden in communication channel during peak business hours. In busy hours, the slow speed of internet causes loss of huge productive time and energy.
4. ***Spamming Problem*** **–** Spamming means sending unwanted advertisement and marketing information and junk mails to the internet users. During internet operation this causes delay and load to internet.

Internet Service Provider (ISP)

Commercial internet service providers (ISPs) extends the facilities to have access to various internet applications and resources for both companies and individuals on payment based on usage. These Service providers are National Service Provider or its agent. They provide very high speed connections to the internet up to 45 Mbps which is called leased line. Users simply connect the national service provider's nearest switching facility. The ISP then transport the internet traffic across its own network to a router with the connection with the other networks in the world.

Leased Line

Leased line is a high speed digital line connection given to the internet users on payment of fees to internet service provider (ISP).

Internet Address

Internet address is assigned to an user. It is for systematic identification of user. It has three parts :

1. ***IP Address*** – It is an unique for a particular machine on a particular network. IP address consists of four sections separated by periods for example 201.204.54.16. IP addressing scheme is agreed by all internet users. IP address is provided by the Internet Service Provider. IP address has the following characteristics :

   - It is globally unique
   - No two machine can have same IP address.

2. ***Domain Name*** – Domain name contains two or more components separated by periods. For example ibm.com , icwai.org , icai.org

   The last component stands for the category of domain name as given below :

   com – Commercial company

   org – organization (non-profit making)

   edu – educational institution

   net – organization directly involved in internet operation.

   gov – government organization etc.

3. **URL** – Uniform Resource Locator

   Unform Resource Locator for identification of a particular internet resource.

   Generally it has the following structure

   Protocol ://server-name.domain-name/directory/filename

   For Example http://yahoo.com/apk/index.html

Internet Protocol

There are various internet protocols. Very commonly used protocols are :

1. TCP/IP – Transmission Control Protocol /Internet Protocol
2. HTTP - Hyper Text Transfer Protocol
3. FTP – File Transfer Protocol
4. Telnet – remote login
5. Gopher
6. WAIS – Wide Area Information Service

TCP/IP

TCP/IP is a family of protocol. TCP/IP is the underlying protocol for routing packets on the internet and TCP/IP based network. TCP/IP has two major components i.e. TCP and IP.

Function of TCP (Transmission Control Programme) :

- Breaks the data into packets that the network can handle efficiently
- Verifies whether all packets have arrived their destination
- Reassembles the data

Functions of IP (Information processing) :

- Envelopes and addresses of data
- Enables the network to read the envelope and forward the data to its destination
- Defines how much data can be fit in a single envelope (a packet).

Hyper Text Transfer Protocol (HTTP)

The protocol used by www is the Hyper Text Transfer Protocol (HTTP). Hypertext is a text that is specially coded using a standard coding system called Hypertext Markup Language (HTML). These links can be through text or graphics. HTTP works on client/server principle. The user tries to link the server where the resource resides. This is why the address on world wide web begins with http:// . These addresses are called Uniform Resource Locators (URLs).

Hyper Text Markup Language (HTML)

HTML is a kind of language which helps to describe text and graphics by the use of some standard sets of well defined tags used for varieties of purposes. The some related texts and graphics taken together to form a page. Pages created with the help of HTML was static in nature in the sense that no information from server could be incorporated in the pages. Now, Dynamic HTML (DHTML) and Extensible Markup Language (XML) are being widely used. Technology like CGI-Perl, Active Server Page (ASP) have been evolved to do processing and update database at server end.

FTP

File Transfer Protocol is used for file transfer one computer to another. It works in client-server technology. A client makes request to have an access to information. The FTP client program searches the file, locate it and transfer the file to servers called FTP servers. These servers act as interface and initiate the transfer process. Steps involved are

- Connection with the FPT server
- Navigate the file structure
- Transfer the file

Telnet

It is a protocol to connect one computer to another. The user which initiates the connection is referred as local computer and the other one which accepts the connection is referred as remote computer. The remote computer may be physically located in the next room, in the same town or anywhere in the world. Telnet also works in client-server technology.

Gopher

It is distributed information system that presents information to the users with the help of hierarchical menu. Interactions between many gophers on internet allows users to search, retrieve or display information on different host computers. Information are stored in many computers called Gopher server can be accessible by a Gopher client software.

WAIS

It stands for Wide Area Information Service. It is basically an internet search tool which can search more than one database at a time thus making searching operation fast.

World Wide Web (www)

It is developed by Tim Berners Lee of MIT, USA. The servers are interconnected like a web and network is world wide. These servers are called web servers. Each distinct file in the web is called web page. A set of related web pages is called web site. The first page of website is called home page. Earlier days, web pages used to contain only text files. With the advancement of technology, web-pages now contain text, picture, sound and animation. It is also referred as W3.

WWW with HTTP provides the following services :

- Creating links between users
- Incorporating references to picture, graphics etc.
- Communicating with other internet protocol

Web-site

A particular user of the internet facilities may develop a web page. This web page contains information of the user. This web page has a definite address which is called the web site address of the user. The other internet users can have access to the web site through the address.

Home Page

The first page of the web site is called the home page.

Web Browser

Web Browser is a software which helps the user to contact a web server. Functions of a web browser are :

- Receiving the requests from the user
- Sending the request the web server for information
- Receives the information from the web server
- Sending it the user

The browser is the interface between the user and the web server. Browser allows the user to have access to both text as well as graphical picture. Browsing graphical picture is time consuming.

Chatting on the Web

Chat means allowing the users directly to communicate to each other. Now the chat facilities have become very popular. By way of chatting, the people can interact with each other and exchange ideas and views. There are some sites exclusively for chat. Some of the places where on-line chatting is allowed are given below :

http://www.funcity.com/chat

http://www.talkcity.com/chat

Search Engine

Search Engine are websites maintaining databases of websites and their contents. When an user wants to locate a particular information, the task is done through a search engine. Searching is done by index for the database. The web search engine on receiving request from an user, searches the relevant information from the database and submits the information for the user. There are many search engines available on the web. Some popular search engine are:

www.goggle.com, www.rediffmail.com etc.

Registration on a search engine is free. Search engine is viewed by millions of people every day. They have become a strong media for advertisement. Search Engine encourages viewers by providing free service. More viewers means better media for advertisement. Their source of earning is through advertisement. A great marketing idea has popularized the use of free internet service.

Managing Website

At the time of designing the website and maintaining the same the following points are to be taken care to make website more effective in dissemination of information and helping the users in efficient operation :

- Modules should be designed according to the objective of the website
- Web pages should be designed efficiently in terms of information set and cost
- Linking of pages should done scientifically to help prompt downloading
- Website should be updated with the changes in information regularly
- Proper authorization must be there for website management to avoid security problem

On-line Information Service on Web

1. ***Search*** **:** An user can search a particular information with the help of search engine. For example, through search someone can get the names of websites which contains the relevant information on the subject of his interest.
2. ***Browsing*** **:** Browsing means searching detailed information on a particular subject from different websites.
3. ***Surfing*** **:** Surfing means browsing with any pre-determined search material. It is only browsing over different websites to have any information of his interest.

Electronic Mail

Now, the use of e-mail has become so popular that it needs no explanation to establish its credentials. It is possible to communicate worldwide over within few seconds. This has revolutionized the world of communication with its magic ability. Any document of file, personal or business-related can be sent with massages as attachment. This has opened a front to save time, cost and hazards in communication.

What needed are :

1. One Computer
2. Internet Connection
3. User's name and e-mail address

e-mail address : Internet connection and e-mail address are provided by Internet Service Provider. e-mail allows the people to send between the computers of the people connected on the internet. e-mail address is the identification of the sender and receiver. e-mail address is unique world over. The structure of e-mail address is

username@host.subdomain.second-level-domain.first-level.domain

example : **icwai@ndb.vsnl.net.in**

***Mailbox* –** Mailbox is used in e-mail to store in-coming message. The receiver is not necessarily be present when the e-mail is delivered to him. All his message will be stored in the mail box.

***Mail Server* –** Mail server basically sends a mail to the e-mail address of the receiver. It does the following:

- It maintains list of e-mail account
- It allows to compose message.
- It sends the message when send button is clicked.
- It arranges the messages of the receiver in the order they are received etc.

***Address book* –** An address book is a place where e-mail addresses of people with whom frequent communications are made are kept. New addresses can be added to it or some existing addresses may be deleted.

***File Attachment* –**The major drawback in e-mail is that the formatted text can not be sent. If a word file containing graphics picture or bulleted list etc is sent, only text will be available and all other things will be lost. The solution for this is to send the document as attachment file to the e-mail address. It also saves time and money.

Activities under e-mail

1. ***Composition :*** Composition of message preparation may be on-line or off-line. On-line means it done when internet is active. In case of big message, the same is prepared off-line and is sent afterwards according to convenience of the sender. Files can be sent along with the message as attachment.
2. ***Sending / Receiving :*** Sending or receiving message means transmission of message from sender to receiver. The sender puts the e-mail address of the receiver and the message is transferred to receiver's e-mail address through the server. Receiver receives it whenever he logs in at his internet address with the password. If the receiver' e-mail address is wrong, e-mail will be bounced back to sender.
3. ***Reporting :*** Reporting means giving the sender the status of message sent.
4. ***Display / Download*** : Receiver can see the message on the computer or he can download the contents in a file or on printer.
5. ***Replying and Forwarding e-mail massages***

This is very good option provided by e-mail program. By pressing the button, the option can be availed. The advantages are :

- Address of the person to whom reply is being made, will automatically come
- Subject also be written automatically with prefix 'Re:'.

- Original massage can be sent back with proper option for ready reference
- 'Reply to author' or 'Reply to all' option is exclusively for author or all to which copy was sent respectively.

6. ***Deletion*** **–** Messages after receiving may be deleted to arrange space in the mailbox.

Effective way of e-mail use

- Massage to be composed off-line to save on-line time
- Address book may be used to save time to pick up the addresses with whom there are frequent communications
- Mails may be organized in different folders to keep track
- Check the mail box preferably during non-peak hours so as to get quicker connection

Advantages of e-mail – mail has become very effective mode of communications in business environment or at personal level. The advantages many which can be summarized as below :

1. ***Speed*** **–** The communication through electronic media is instantaneous from one corner of the globe to the other.
2. ***Cost*** **–** Cost is very low compared to any other mode of communication.
3. ***Sharing information*** – Same message can be sent to multiple receivers at one go giving all e-mail addresses of individual receivers.
4. ***Documentation of communication*** **–** An e-mail keeps date and time which is preserved with the message. This is useful for the purpose of auditing the communication in case of future complicacy.
5. ***Powerful media for communication*** **–** The multimedia combining text, graphics etc. can be sent as attached files.

Voice Mail

Voice Mail is a system of recording the voice of the speaker (caller) on a recording media and massage is passed on the appropriate user. This system is used in case of STD calls. It has the advantage of recording the massage for future use by the appropriate person. Even the massage can be distributed to different users through e-mail after conversion of massage in digital form.

E-Commerce : The possibility of almost frictionless access to information globally has brought the idea of business transaction through internet which in termed as E-Commerce. IBM has promoted the E-Commerce concepts and tools through different solutions and developments. The concept of E-commerce is that the consumers can have access to global market, advantage to choose the best, free option to explore the terms and conditions for procurement of an item from different vendors etc. These can be done sitting at home or office without having the painful exercise of visiting market and negotiating terms and conditions. The instantaneous gathering of information and providing decision based on pre-determined criteria are to be taken by the system.

To understand how it works, let us see what are the components involved in it :

- Customers
- Suppliers

- Service Provider
- Channel partner (distributor)
- Regulatory authority

A consumer interacts with the online system through web browser. A consumer first interact then uses hyper link to access a shopping mall. A Shopping mall is where a customer first visits for shopping spree and there may be many pages in the shopping mall. Business process follows the path :

- Consumer selects a store
- Link to the merchant server
- Customer selects an item from the e-shop
- Receipt of payment by supplier through credit card
- Obtain payment authorization
- Physical delivery of the item

Transactions in E-Commerce

- Consumer accesses a shopping mall and select a shop for purchasing certain item.
- Shopping mall serve the access to the merchant for a selected shop.
- Merchant system presence the home page to the consumer.
- Consumer selects the desired goods.
- Consumer interacts with the merchant system and make the payment.
- Merchant system accesses his bank for authorization of the consumer payment.
- Authorization of payment by the bank.
- Merchant system informs the consumer that the payment is accepted and transaction is completed.
- The consumer bank informs the customer of the money transfer.

Advantages of E-Commerce through Internet :

1. ***Easy access to global information :*** The Suppliers will put their product technical specifications and other commercial information in the world wide web. This publicity will involve little cost. Customers can make enquiry and place order through internet. Easy access to internet will give him opportunity to compare terms and conditions for commercial transaction.
2. ***Effective Advertising Media :*** The consensus on low cost provision for advertisement in www will be a advantage in the hands of suppliers to open up their products to new customers who prefer internet for their shopping needs.
3. ***Free Entry :*** The powerful search engines are encouraging the users to have access free of cost. The prospective buyers can take the advantage.
4. ***Market driven strategy :*** The suppliers can judge their product response by analysing the visitors to the website and number of matured order and start their strategic decisions to carry on with the present trend or go for luring more buyers with better offer in terms of quality and price.

Impediments in E-Commerce

The research conducted by many experts on impediments of e-Commerce. Some of them are identified and given as follows:

1. Security : When an organization uses the internet to engage in e-commerce, it is likely many of its information are exposed to security risk, fraud and abuse. Out of them the most serious is credit card information.
2. Legal Issues are many like protection against fraud, passing sensitive data to strangers etc.
3. Cost of hardware, software and maintenance
4. Lack of expertise
5. Need of training
6. Uncertainty of market

Issues covered under E-commerce

- Legal issues relevant to e-commerce
- Evolving business practices
- Relevant legal standard
- Proper guidance
- How to create enforceable digital contracts for small goods or services
- Digital transaction will be enforceable and valid as a traditional paper based transaction
- Signature as an evidence
- Time, date-stamping to provide proof of dispatch, receipt, submission etc.
- Authentication procedure
- Legally binding commercial transaction etc.

E-commerce is progressing fast but legal and control provisions have not yet been developed in the form of insuring valid contractual obligations. Thus there is a need to develop legal mechanism. The law has been slow in relation to the progress of technology. Parties to electronic commerce transaction have worked within the system of traditional, contract law, making adjustments to fit into the new business practices.

Validity of agreement and enforceable by law

Two requirements of a valid contract :-

i) Mutual ascent / intent by the parties to come into contact

ii) Sufficient definite terms

Here definite terms involve mechanism on actual performance, such as delivery of goods or services, payment for them or return them.

The provision for enforcing a compliance of a failure to perform according the contract is a breach of contract. Fundamental objectives of contract law is to protect a party who accepts a promise in a properly framed agreement, from injury as result of breach by another party. Law enforces various avenues of recourse to enforce his right under the contract law. Injured must proof his injury and damage and the party who breaches may face several types of liabilities.

Binding of contract

- Protection of system error, programming error, human error.
- Evidence in case of digital agreement
- Invoices and payments related to e-mail must be authenticated
- Security policy defines some of the controls and counter measures that must be provided.

Auditability

In order to resolve, the parties involve will produce evidence to support their cases. The principal security requirement here is that the integrity of the audit trend must be assured. Integrity of the electronic data file may be manipulated without any trace. It will create lot of problem. Necessary security service is essential. Proof of source authentication and integrity of messages are to be preserved.

Virtual Reality

Virtual Reality is a programming language to simulate the model in a such a fashion that it looks like real. This tool is being thought of to be useful in advertising in web-sites for an effective e-commerce business.

Electronic Cash

Electronic cash or e-Cash or Digital Money is to provide the means to transfer money between parties in the network. Steps involved are :

- Consumer request his bank to transfer money to e-mint to obtain electronic cash.
- Consumer bank transfers money from customer account to e-mint
- E-mint sends the cash to consumer. Consumer sends the electronic cash in a hard drive or a small card
- Consumer selects the goods and transfer the e-cash to merchant
- The merchant provide the goods to the customer
- The merchant sends the electronic cash to his bank
- The bank redeem the money from the e-mint
- e-mint transfers the money to the merchant's bank account

Benefits of Electronic Cash

- Potential fraud is reduced- when the bank receives the electronic cash, it verifies the serial number, it deletes the serial no and takes it out of circulation forever. The same number can not be re-used.
- Preference of Merchant – Merchant will prefer an electronic cash, since it guarantees the payment
- Confidentiality of customer – Customer's confidential information regarding his Bank Account etc. is not disclosed.

Digital Subscriber Line Technology (DSL technology) : DSL technology is a powerful technology. It will have three compelling advantages :

- High speed data transfer rate (128 Kbps to 6Mbps)
- Meeting the need of growing brand-width for application need
- Low implementation cost

Electronic Data Interchange (EDI)

Electronic Data Interchange is a process of exchange of structured business information (documents) among various agencies involved in the process of transaction through electronics. Purchase orders, invoices, remittance advice etc. are the documents which need to flow smoothly in the business process. EDI is the service provider in the process.

EDI's job is to receive and transit the documents among the trading partners. Traditional EDI communication route is through value added network (VAN), which is a third party service provider that receives, stores and transmit data. EDI's process comprises three sub-systems :

1. **Translation :** EDI software converts files from trading partners into EDI standard format, called EDI document
2. **Transmission :** EDI documents are transmitted using mutually agreed communication method
3. **Retranslation :** When a trading partner receives a transaction, it is retranslated with the help of EDI enabled software into a format which can be used as its own business document format.

EDI documents are developed for the following reasons :

- To ensure smooth transmission of data
- To make data suitable for storage in database

EDI will be necessary requirement for Indian exporters to exchange business information and documents. The US, India's largest market will make it mandatory

To flow data through EDI for international trading transaction. In India, EDI will start operation in internet business. RBI, Ministry of Commerce, Customs Department, Airlines, Airport, Seaport, DG Foreign Trade etc has already agreed for implementation of EDI documentation in foreign trade. Major problem has been the inter-connectivity of the various organization.

Advantages of EDI

1. Reduced manual entry leading to an increased accuracy
2. Reduced clerical overhead resulting lowering cost
3. Faster delivery of data
4. All business transactions are immediately acknowledged.

Electronic Fund Transfer

Bank to Bank Transaction and commercial transaction through electronic needs confirmation and authentication. The transactions involved in the process are :

- Buying and selling of foreign exchange
- Inter-bank deposits

- Payment through credit card

The major issue of security against data leakage and protection mechanism from Merchant fraud.

Secure Electronic Transaction (SET)

Master Card and Visa International have been developed. SET protocols which are :

- Merchant will have no access to credit card information
- SET requires authentication of trade parties prior to commencement of processing

System adopted by SET :

Encryption of both information with secret keys :

i) ***Financial information*** : Credit card information which is a private matter between card holder and card issuing agency

ii) ***Non-financial information*** : Details of goods purchased, mailing instructions, cost etc. which are private information between trading parties.

Intranet

Intranet is a in-house version of internet. Intranet is a private network. It uses the same mechanism of communication - internet software, TCP/IP protocol and web browsers. But there is difference in terms of behavioural environment. Internet operates in open environment whereas intranet operates in controlled environment. Typically intranet operates between different offices in an organization. An intranet is a perfect solution for small and disciplined team scattered over a wide geographical area. Companies are increasingly using intranet to broadcast internal information generated out of transaction processing at different points among themselves and to the controlling branches. Following are basis features of Intranet:

- Based on internet protocol which can be expanded worldwide.
- Based on architecture with flexible expandability
- Low cost compared to internet facilities
- Facilities of handling multimedia data
- Communication facility limited to the organization – better control on data integrity
- Serves the work of information mobilization for MIS

When a corporate organization has its sales office dispersed over a wide area and plans for closer control over the target market with the help of better service, it needs continuous feed back from market. The intranet mechanism can help it to achieve the goal with ease and in a more cost-effective way.

Specific Application of Intranet

1. Sales Management
    - Production information
    - Price list
    - Information on sales
    - Analysis of local competition etc.

2. Customer Service
    - Conduct training to Customer Support Team
    - Determine the status of particular product / Customer
    - Latest orders status
    - Publish technical support bulletins etc.
3. Accounting Information
    - Monitoring company's stock price
    - Publish the public annual report
    - Preparing list of debtors etc.

Extranet

An extranet is a business-to-business intranet i.e. inter-organizational information system. It is an extension of intranet concept linking all intranets of related organizations for mutual benefits and sharing information among themselves. Instead of sharing information within the information within one organization, it goes beyond. Generally it is opted when the two organizations are closely related by way of same group of entrepreneur house or they are strategic partners for a common corporate objective. In extranet, same infrastructure components as the internet, TCP/IP protocol and Web browser are used.

On Extranet, each participating companies have to have a common understanding for a common objective. It may be sharing of information or sharing of software or sharing of technology in the computer media. Extranet is commonly opted among the companies involve in supply chain management.

Benefits of extranet :

- Better corporate communication environment
- Low communication cost
- Faster processing of information flow etc.

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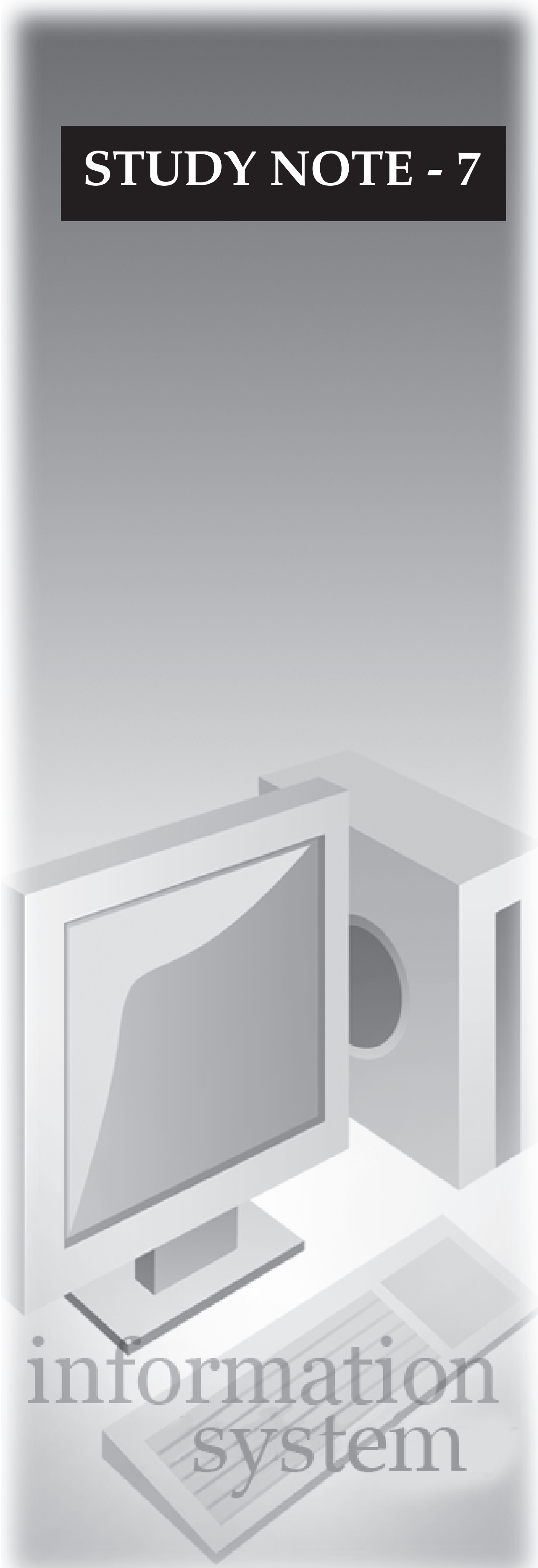


Information Management and Decision Making

7.1 Data Source

Data source may be internal or external. Internal data are from transaction processing of the organization. External data are those which are collected from outside an organization but relevant to the organization for its use. These data may be from a published reports from survey, studies, observations or from internet or from other sources. Example –

- Market information
- Product information
- Technology information etc.

7.2 Data Quality

Quality of data is the most important aspect as far as its use is concerned. The classic expression on the importance of quality of data for data processing is represented by the word 'GIGO' – Garbage In Garbage Out. This word was devised to forewarn the systems people to be all careful for ensuring quality of data for the success of an information system. The poor quality of data means incorrect, incomplete and ambiguous data. A poor quality data may cause great damage in reporting and action initiated by it. The aim of good quality of data is to provide information which must have these quality:

- Relevance
- Timeliness
- Accuracy
- Completeness
- Consciousness
- Understandability

7.3 Data Storage and Management

The amount of data increases exponentially with time. The requirement of preserving long-term data has become a great burden on an information system. Of course, the storage capacity of computer has become very high and the cost of storage has gone down also. With this development in information technology, a system favours preserving long-terms data for better in-look in the information analysis. The basic advantage of a computer system is the standard organization of data set and ease of retrieval. The factors which guide data storage are:

- Requirement for analysis and purpose of use
- Selection of data management tools
- Data organization
- Adherence of legal requirements
- Security of data etc.

7.4 Data Warehousing

The data warehousing is the concept of data integration by way specialized data storage and retrieval technique. The core of data warehousing is multi-dimensional databases. The basic objective of data warehousing is give right kind of expert analysis of data and feed the decision makers with right kind of information for effective decision to run the business efficiently.

The need for data warehousing has come from increased competition and demand for more and accurate information for precise decision making. Data warehousing can translate the data in common format and store them scientifically for faster access. Combining the related data is the crux in the approach of data warehousing. Thus, database design has a definite key role in making the storage efficient. Providing sensible information is only possible through analysis of related data.

Steps involved:

- Development of hardware and software infrastructure
- Building sound corporate database
- Establishment of communication network
- Managing smooth data flow from multiple operational points
- Building proper check and security measures from misuse

Critical factors involved in data warehousing:

- Heterogeneous data set and their translation in common format
- Organization of database
- Capability of software tool
- Judgement on transactional period for storage of data

Advantages:

- Effective, efficient and convenient data storage
- Elimination of duplication
- Lower storage of cost
- Faster navigation through related information
- Reliable data
- Consistency in reporting
- Better decision making

Strategic use of data warehousing in different business environments:

- Customer Service
- Sales Promotion
- Market analysis of new products

- Trend Analysis
- Inventory Control
- Sales decisions etc.

7.5 Data Mart

Data mart is the simple form of data warehousing. In other words, it is a scaled-down version of data warehousing. Data marts of a company are generally created with specific objectives. It may be function specific. The advantages of creation of data mart are low cost and less time requirement. Data marts are created with a specific focus. For example, data marts may be created for marketing department with competitors information only to develop business strategy to improve market share. This kind of approach is meaningful as far as relevant information base is required. Instead of waiting for comprehensive data warehousing, data mart sometimes provide tremendous services to meet immediate and specific information need.

7.6 Data Mining

Data mining name is derived from the similarity of searching out valuable business information from a huge database and mining of valuable ore after locating it from below a huge mountain or sea. The data mining is the result of long process of research on possible methods of proactive information delivery. Data mining is extraction of data from multiple data sources by way of interactive and analytical software tools. In other words, it is the process of finding the relevant information from a large database with the help of 'expert' software and using the analytical tools for data analysis which turn them 'knowledge' for the decision makers. The decision makers' job becomes easy as they have less botheration on how the analytical tools work. They make queries and results based on 'expert tools' flow in their hands to make the process more easy going, sophisticated and dynamic.

Data mining involves intelligent probing on data to make reliable and predictive information from a large data base. The software tools available for data mining provide the following types of services:

- Neutral computing based on data available to identify potential areas and suggest precautionary measures in the business process
- Intelligent agent's work in retrieving most reliable information
- Support of special expert with necessary IT tools to extract appropriate dataset and use good mathematical model to make predictive solutions
- Optimization of business process variables with Operation Research techniques and guiding business decisions
- Evolving industry standards on many business processes

Advantages of Data Mining:

- It provides finite set of values of variables with other relevant information to understand their trend and behaviour
- It determines the significant and possible variations in the variables

- It helps in building predictive model for future values of target variables
- It is a guiding force for proper decision making

7.7 Knowledge Management

Knowledge is a mix of information, experience, evaluation. Thus, information system in an organization is the key resource on which knowledge base depends. The main function of knowledge management in corporate world involves the process development of minds of decision makers through continuous flow of right kind information and their critical evaluation. Steps involved are :

- Creating the information data base and constant updates
- Creating technological infrastructure
- Developing analytical skill
- Continuous feedback system
- Creating culture of sharing – exchange of information
- Capturing knowledge (analytical information and expert opinion)

It is a process of accounting and creating knowledgebase for the organization for facilitating sharing of knowledge by managers for efficient management throughout the organization. The crux in exercise of knowledge management is to transform the data warehouse into knowledge base. Knowledge base means:

- Best company profile
- Performance measurement tools
- Best control practices
- Complex business environment parameters

The knowledge management has demonstrated a good account of success in deriving effective business solution. This tool is in developing process and its potential is enormous in guiding the model management in making decisions relating to market, product, technology and so on.

- It is an intellectual capital
- Knowledge base is assimilation of best experience and business process
- It is a collection of effective business solutions history
- Comprehensive corporate data base.

The process of creation of knowledge management involves the great deal of technical tools which are:

- Knowledge identification
- Storage
- Organization of information
- Retrieval system
- Dissemination system
- Effective use

Knowledge base stands in one place on the organization in a structured manner so that it is accessible by the users in the organization. The aim of knowledge management is to guide the managers in taking appropriate decisions, prevent managers to do the same mistakes and forecast on business outcome and showing the path of success.

Sources of Knowledge.

- Information base
- Past experience
- Expertise in specialized field
- Sophisticated analytical ability with mathematical tools

Benefit of Knowledge Management:

- Increased ability to compete
- Richer knowledge stock
- Effective utilization of resources
- Stronger 'base of ideas' for innovation

Information requirement for Management Accounting has the following objectives:

- Collection and presentation of information relating to business
- To facilitate control
- To improve the users knowledge
- To add the value of the product or service
- To plan for the future on the basis of the information on customer's opinion, computer behaviour, and new technology

Social and organizational impact:

- Impact of development on telecommunication
- Interpretation and use of intelligent agents software
- Cultural dimension of IT acceptance
- Management of chain and potential staff reaction
- Growing awareness of remote working

7.7.1 Knowledge Management for Innovation framework:

- Identify business arrears and processes that are suitable for innovation
- Identifying change levers; those tools that can be used to innovate
- Development process vision; statement of purpose for the processes
- Understanding the existing processes
- Designing and prototyping new processes

7.7.2 Innovation culture:

- Change in the culture of the organization
- It is not sufficient to allow managers to invent new processes by stumbling across opportunities
- They should be encouraged to be continually on the look out for new and better ways of doing things
- The value chain analysis

7.8 Business Process Re-engineering (BPR)

Business Process Re - engineering is a continuous process of rethinking, re - assessment, re - designing and re-valuation of each elements of business process. Re-engineering gives stress on bringing changes to improve performance. It comes through 6R's.

Business Process Re-engineering
• Realization for change • Requirement • Re - thinking • Redesign • Retooling • Re-evaluation

Success of the BPR lies in correctly understanding the shortcomings in the existing system and risk in the changes and undertaking the technical feasibility study of the proposed system. BPR is an all embracing exercise to bring changes in business process such as overhauling organizational structure, improving management system, bringing in new work culture and replacing old business system with a new one.

Success of BPR depends on effective planning on what are the changes to be brought, what will be their priority and how to effect the changes. Obviously, it involves a great deal of trial and error exercises. Right kind of analysis of causes of failure is needed. The knowledge gathered gives the right direction to avoid mistakes and to ultimate success.

Most critical part of implementation of BPR is transformation of workforce i.e. changing human behaviour and attitude. Success index depends on extent of co-operation from the employees of an organization.

Origin and scope of BPR:

- Fundamental rethinking and redesigning of business processes to achieve dramatic improvement in critical measure of performance such as cost, quality, service and speed.
- ***Process identification*** – an organization or a department is broken into series of processes.
- ***Process rationalization*** – identification of the value addition by each process and elimination of non-essential processes.
- ***Process redesign*** – the remaining processes are redesigned so that they work in most efficient way.
- ***Process reassembly*** – the re-engineered processes are implemented resulting in efficient performance in tasks, department and the organization as a whole.

Steps involved in BPR:

1. Begin Organizational Change
   - Assess the current state of organization
   - Understand the existing process
   - Explain the need for change
2. Develop vision for change and success
   - Communication campaign for change
   - Making employees understand the need for change
   - Projections of outcome of change
   - Remove the fear psychosis on security of job
3. Devising BPR plans and programmes
   - Evaluate the existing business strategies
   - Discuss the issues relating to customers' desire
   - Identify new business opportunities
   - Select the processes to be re - engineered
   - Identify potential barriers against implementation
   - Formulate new process performance strategies
4. Change in work practice and culture
   - Brainstorm using BPR principles
   - Use customer value as focal point
   - Explain the new values and culture required
   - Establish re-engineering teams, cross functional workgroups
   - Allow the workers to make decisions
5. Establish new business system
   - Prepare document for new organizational structure
   - Draw new work flow diagram
   - Create model on new process steps
   - Describe new technology specifications
   - Redesigning the information flow requirement
6. Perform the transformation process
   - Develop a migration strategy
   - Map new skill requirements
   - Train the employees on new processes
   - Reallocate the workforce
   - Transform the organization

7.9 Expert System

According to CIMA, an Expert System is an application software system which is used to store data relevant to a particular subject area and to provide solutions to problems requiring discriminatory judgement based on that data.

Expert system is a software which derives extraordinary intelligent solution like an expert. The knowledge of an expert in invaded in the software with solution options for different complex problems situation, particularly, unstructured problem situation. Here the expert knowledge is knowledge of specialized field and solutions sets at different problem situations.

For example, knowledge of expert marketing management for experts system in marketing, knowledge of legal expert for expert system in legal field, expert knowledge of taxation for expert system in taxation. This expert knowledge and history of different unstructured problem solutions are stored in organized manner so that the related expert system can use the data base. The expert system is not a simple management information system. Rather it helps in involving solutions in complex problem situation. The component in expert systems are

- Data management
- Expert knowledge handling tools
- Complex problem situations and framing corresponding solutions sets.

7.10 Artificial Intelligence (AI)

Artificial Intelligence refers to behaviour of computer system which seems to be intelligence of the computer itself. As you know the computer does not have power to act on its own, the intelligent solutions from a computer system is termed to be Artificial Intelligence. In fact, this phenomena is exhibited by a computer system out of the expertise of the software which has the capability to interpret the problem situation and use the knowledge base to evolve intelligent solutions. The artificial intelligence is closely associated with expert system. It is only the expert system which can exhibit artificial intelligence.

7.11 Decision Making Process

Decision making is an important managerial function of choosing a particular course of action out of several alternatives. Developing decision making system is an integral part of an organization. For a good decision making system, the following criteria must be followed:

- Creation of fair, free and sound decision making environment
- Establishment of ground rules for decision making
- Formulation of organizational policy and procedure
- Establishment of proper Information system
- Training to junior managers on judgement skill and art of decision making

Decision making is a process to improve operational efficiency of the organization. The objectives of decision making are:

- To make effective use of resources
- To have better control measures
- To improve operational efficiency
- To augment profitability
- To face competition

Steps in decision making process

Decision making process follows a scientific system and the steps involved are:

i) Identification of problem and diagnosis of the problem

ii) Collection of relevant Information

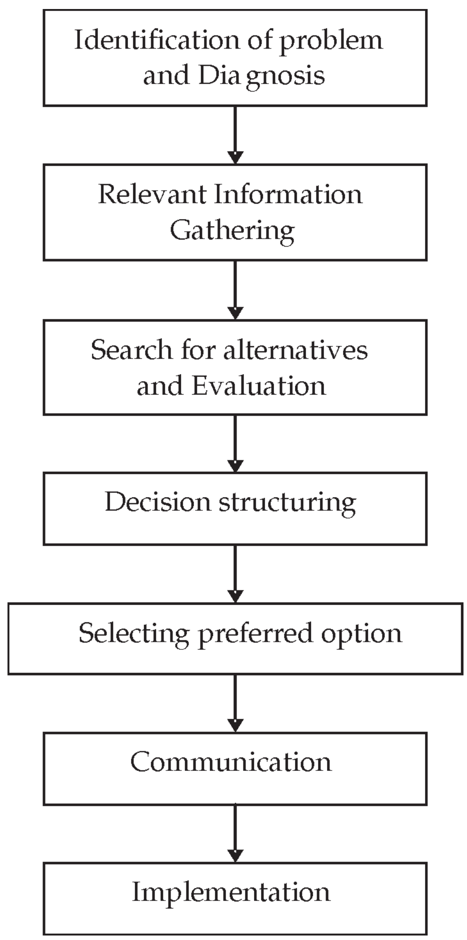
iii) Search for alternatives and evaluation of them

iv) Decision structuring

v) Selecting preferred option

vi) Communication to relevant action points

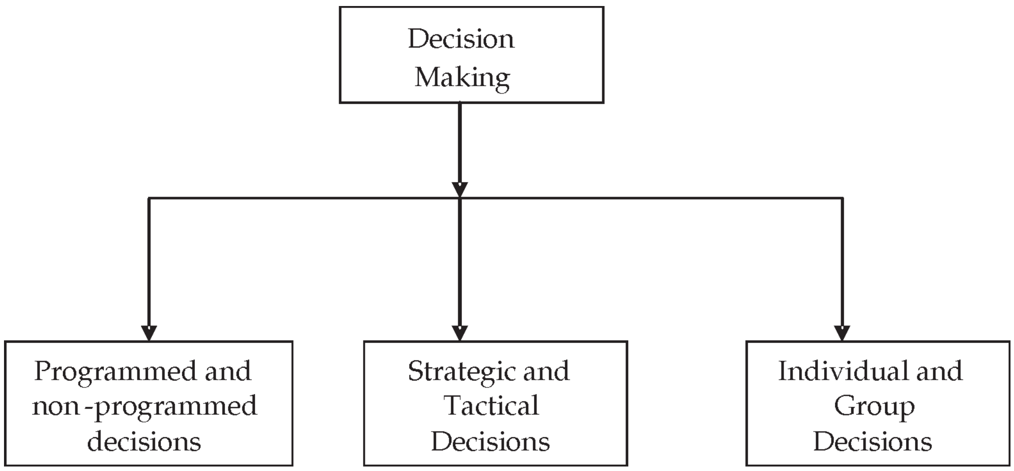
vii) Implementation



The following factors determine the quality of decision making:

- Analytical ability and experience of the decision maker
- Flow of relevant information
- Tools available for information analysis
- Reconciliation with unavoidable factors

Timely implementation



Programmed and Non-programmed decisions

Programmed decision making refers to those decision making process which are based on some standard set of procedure established by the management and according to scientific principle of management. In case of programmed decision making, supporting information sets and reports are standard, well defined and well structured. Naturally decision making process is simple and based on some guidelines. For example, stores ledger summary and material consumption reports may help in decision making on Inventory control.

Non-programmed decision making refers to those decision making process which does not go by any pre-determined set of guidelines. Normally this type of decision making takes place to handle special business situations with the help of experience, judgement and vision of the decision maker. In case of non-programmed decision making, information are unstructured and external environmental information is a must along with internal information sets. For example, for decision on business policy many non-standard information like technology change, competitors market share etc. is required apart from internal information of sales of different products.

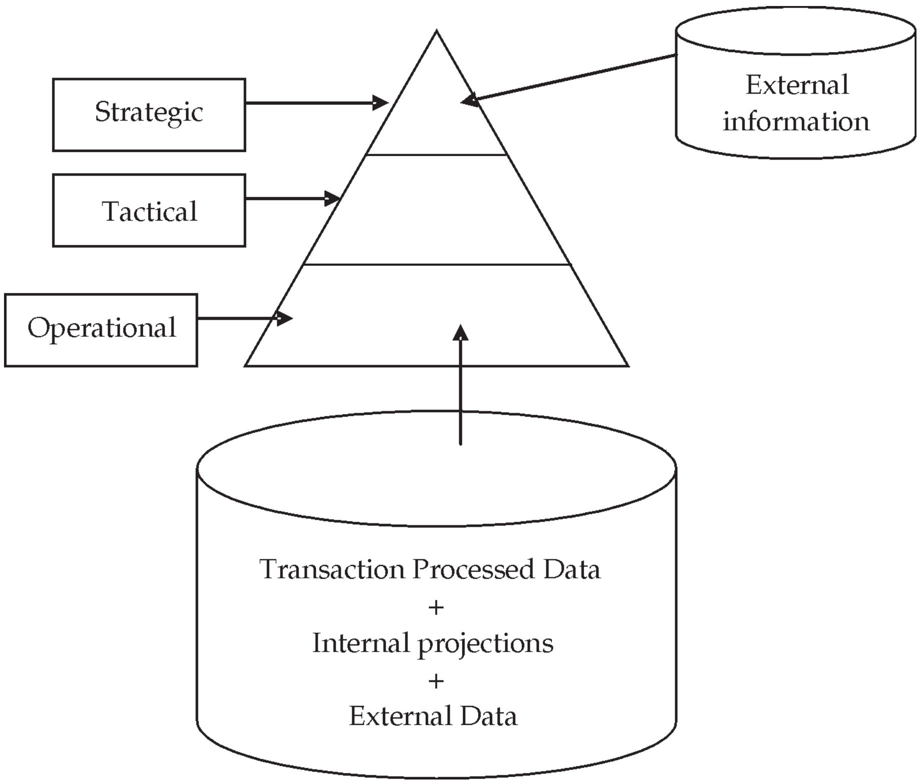
Decision hierarchy

Decision making process follows a well established hierarchy. Different levels of management are involved in different types of decisions. This type of decision depends on the level of responsibility and their controlling activities. Decision may be of different kinds. The diagram showing the decision hierarchy explains lower level management takes decision on operation, whereas middle level on tactical and top management on business strategy.

Top Management **–** Top management is concerned with strategic decisions like diversification, technology acquisition, new market exploration, strategic business alliance, takeover, merger etc.

Middle Level **–** Middle level management is generally involved in tactical decision making with the help of performance analysis, budget variance analysis, devising better productivity mechanism and control etc.

Operational Management **–** Operational management staff are mainly involved in scheduling the activities, keeping track of progress of day-to-day operations and decisions of well structured problems etc.



Strategic Decision Making

Strategic decision making is concerned with the issues relating to long-term effect on the business growth and prospect of the organization as a whole and involves both internal and external factors. Strategic decision making process involves the following:

- Assumptions of possible future state of business environment
- Generating alternative strategies
- Enhancing the problem prevention capabilities
- Decisions based on different business scenario

Important Financial decisions:

- Capital structure decisions
- Capital budgeting decisions

- Working Capital Management
- Asset Management
- Tax Planning
- Profit Planning etc.

Important decision in Marketing Management:

- Product pricing
- Sales incentive
- Sales promotion activities
- Market Research and intelligence
- Product development strategy
- Product pricing
- Customer service etc.

Important decision on Production Management

- Volume of production of different products
- Schedule of production
- Manpower deployment
- Cost control
- Quality control measures etc.

Important decisions on Human Resource Management

- Recruitment policy
- Placement
- Wage negotiations
- Training scheme
- Incentive scheme etc.

Important decisions in Project Management

- New project/modernization project
- Technical consultancy
- Investment planning
- Long-term and short-term project funding
- Equipment procurement etc.

Tactical Decision Making

Tactical decisions are concerned with issues having short-term effect on the business. Primary aim of this type of decision is to effective use of resources, remove any imbalance among different factors of production and improve productivity of factors of production. Often decisions are related to acquisition of resources to help strategic decisions.

Operational Decision Making

Operational decisions are related to the effective use of resources acquired out of tactical decisions and aim of these decisions are to have effective control of the use of resources in day-to-day business activities. Decisions are directed to achieve the target as decided by tactical decisions.

7.12 Decision Support System (DSS)

According to CIMA, Decision Support System (DSS) is a collective term to describe the various types of software, principally modelling or simulation, which provide input into management's decision making process. The 'what if?' analysis produced by spreadsheets is a typical example.

Decision support system is an IT tool based on models for interpretation and analysis of data and presenting the same for facilitating decision making. An expert system is within the DSS so that unstructured problems are also taken care.

Decision Support System has the following three characteristics:

i) Support semi-structured and unstructured decision making

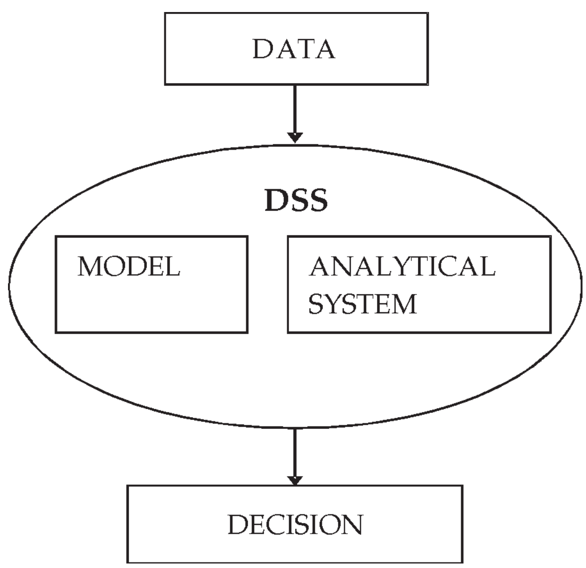
ii) Use model for solutions

iii) Flexible to respond the changing need of the decision maker

Structured or Programmed decision making is with the help of using data in a simple related decision making program which is based on technical knowledge on a particular area.

Unstructured or semi-structured decision making process involves a great technical expertise of the all subjects of all related fields and building model to handle the information to derive solution set.

Decision Support System



7.12.1 Components of DSS :

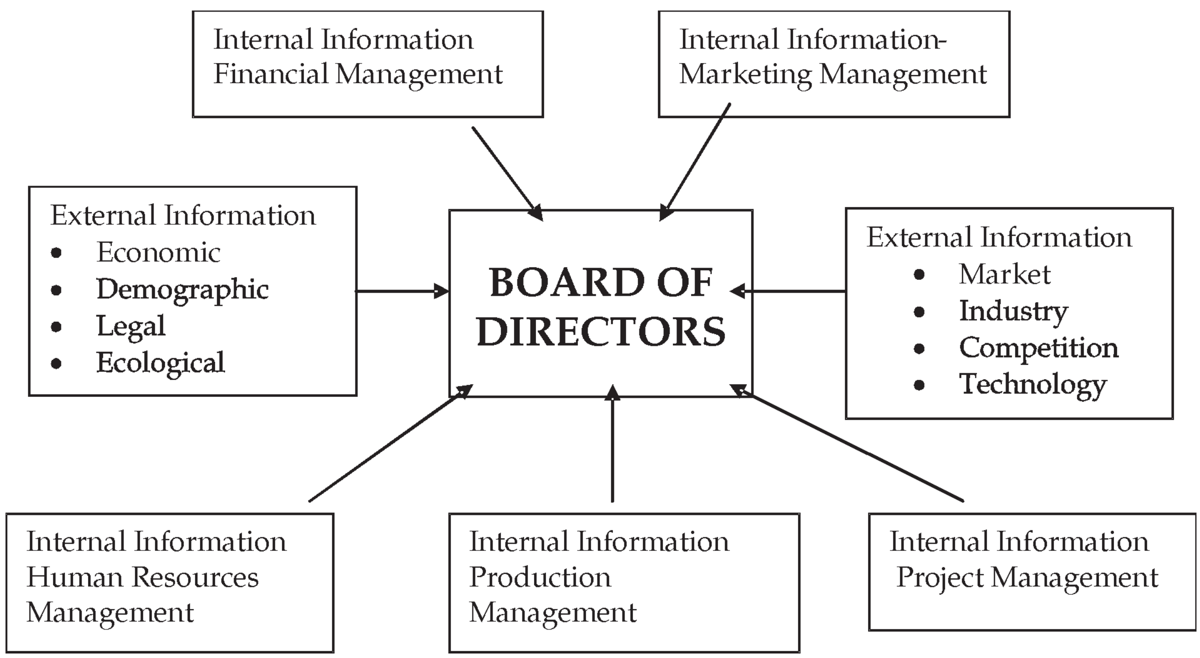
A DSS has the following three components:

i) **Databases** – A DSS must have one or more databases containing all relevant information. The system will extract the set of information from database with data-mining tools.

ii) **Model base –** Model base is the brain of a DSS. For example, mathematical models on Time Series analysis, Linear Programming, Statistical Quality Control will be tools used to solve many financial problems.

iii) **Technical Expertise –** A DSS system must have technical expertise in the domain field to understand the nature of information, nature of problems, appropriateness of model and additional intelligence required to handle the unstructured or semi-structured problem situations.

7.13 Flow of Information for supporting decision making



STUDY NOTE - 8

Management Information System

8.1 Management Information System

Management Information System is a systematic process of providing relevant information in right time in right format to all levels of users in the organization for effective decision making. MIS is also defined to be system of collection, processing, retrieving and transmission of data to meet the information requirement of different levels of managers in an organization.

According to CIMA-

MIS is a set of procedures designed to provide managers at different levels in the organization with information for decision making, and for control of those parts of the business for which they are responsible.

8.2 Objectives of MIS

- To provide the managers at all levels with timely and accurate information for control of business activities
- To highlight the critical factors in the operation of the business for appropriate decision making
- To develop a systematic and regular process of communication within the organization on performance in different functional areas
- To use the tools and techniques available under the system for programmed decision making
- To provide best services to customers
- To gain competitive advantage
- To provide information support for business planning for future

8.3 Basic Features of an MIS

8.3.1 Management Oriented: The basic aim of MIS is to provide necessary information support to the Management in decision making. Naturally, the design of MIS is framed keeping the consideration of requirement of management of the organization. The management plays the most important role to develop the system specification of MIS to ensure the information need of different levels of management.

8.3.2 Timeliness: One of the most important issues involved in the effectiveness of MIS are flow of information at right time to the user level of management.

8.3.3 Integrated: Disintegrated information from different sub-systems becomes too much clumsy in decision making. Information from different related functional areas is to be integrated to make it meaningful for the users. In today's business environment, the different parameters of business process have a complex equation in an overall impact on the outcome. To understand the combined effect, linking them with the help of different analytical models is essential.

8.3.4 Simplicity: An MIS System should be as simple as possible so that people at operation and users do not feel any hazards. The success of a system lies in the acceptance by operation staff and users. A good amount of planning is required on the part of a MIS designer to make it simple keeping in mind the need of information at different levels of management. The deigning skill of database and analytical models decides the quality of MIS.

8.3.5 Reliability: MIS system should provide most reliable information. For that what is needed the skill in design and efficiency in programming to develop the system. More important is a thorough check of input information, process flow and output reports on regular and routine basis.

8.3.6 Consistency: The input data and output reports must follow some standard norms so that consistency is preserved.

8.3.7 Relevance: Only relevant information flow at different levels of management helps in increasing the effectiveness of MIS. In other words, information of right quantity improves the efficiency of the users in the use of information for their decision making.

8.3.8 Flexibility: MIS should be flexible enough to take care of changes in the environment in the business system.

8.4 Implementation of MIS

For establishment of MIS in an organization, the following steps are followed :

8.4.1 Analytical study on information requirement: A joint efforts by systems experts and management experts is required to understand the exact need of information at different levels of management and how to assimilate them from data flow from different sources. The anticipated change in the need of information may be kept in mind while planning the design in order to provide sufficient flexibility in the system.

8.4.2 Determine the sources of information: Once the first step is understood, it is to see how to get the required information and their sources. If required, data recording system may be changed at different points so that exact data flow is ensured and the same can be done without much hazards. For the sake of simplicity of the system reorientation in the physical flow of data has to be done.

8.4.3 Establishment of right kind of data processing environment: The important step involved in MIS designing is arranging the right kind of tools for processing i.e Computer System and infrastructure in terms of software and skilled manpower. The proper scheduling of processing is equally important to ensure smooth flow of information.

8.4.4 Selection of software: One of the important factors of success for MIS is quality of software. Software must fulfill the following criteria :

- Compatibility of hardware
- Capable of taking load of data volume
- Have the support of software for required database
- Capable of supporting the communication network
- Satisfy the design specification of system architecture – Central data processing or distributed data processing

8.4.5 Database design : In database design the important issues involved are sub-systems in the organization and the logic of integration. Technical knowledge of database and knowledge of application systems, their control requirements and designing of reports are essential for efficient designing of database.

8.4.6 Support of top management : To ensure the smooth functioning of MIS top management support is required. Top management will support only when they are convinced about the benefit of MIS of the organization and confident of efficient performance of processing and regular reporting. Thus, for support of top management, efficiency of MIS has to be established.

8.4.7 Manpower: Arrangement of right kind of manpower with proper skill is the most consideration for successful operation of the system. Proper planning for training of manpower involved in transaction processing and report generation under an MIS system is required to take care of future development of the system.

8.4.8 Integration of information: At the time of designing the data bases, provision for integration of information from different sub-systems is essential so that comprehensive information flow can be of great use for strategic planning.

8.4.9 Evaluation, maintenance and Control: The effectiveness of an MIS system is evaluated by the capacity of its fulfillment of requirement of information by the management. Evaluation is done by ascertainment of the views of the users. Maintenance is needed to take care of the gaps, if any, for further growth and for regular smooth functioning of the system. Control means establishment of checks for input data, processing and output to ensure correctness of reports. Proper maintenance and control on effective operation of MIS required to ensure protection from hazards and smooth functioning on a routine basis.

8.5 Different Approaches for developing Management Information System

For developing, three different approaches are generally practiced which are given below :

8.5.1 Top Down Approach **:** Top Down Approach starts from the identification of information requirements of different activities of the organization by the top management in order to have information support in strategic and tactical decision making and designing the information system accordingly. Top Management provides the guidelines for basic objectives, policies and plan for developing these sub-systems. In other words, this approach designs a model of information flow and same model is used in developing all the sub-systems under the MIS.

Each Sub-systems will have different modules and they are collectively integrated to form a sub-system. The approach of integration is same for all sub-systems. The implementation of different sub-systems is done on the basis of broad guidelines of the top management. Integration of all sub-systems is done at the end to form a comprehensive MIS for the organization. The implementation process is very scientific, systematic and simple.

8.5.2 Bottom Up approach **:** In the Bottom Up Approach, each sub-systems for different functional areas like payroll, Sales Management, Production Management , Inventory Control System are developed according to the specifications for each sub-systems on the basis types of input documents, flow of information and output requirements. There is no common approach for system development. Rather, the sub-systems are developed purely on the basis control information requirements for each sub-systems and guidelines generated by the manager of the respective functional areas.

The next step in the bottom up approach is to integrate the information of these sub-systems for a comprehensive MIS for the organization. This step is a complicated one in this approach. The data base structure of different systems, flow of information and links among them are to be understood thoroughly to have proper integration. Sometimes intermediate databases are created to collect all relevant information from different sub-systems for integration.

***8.5.3 Integrative Approach* :** This approach in a more scientific approach for easy integration of sub-systems and takes care of the limitations in the other two approaches described above by way of better planning.

Under this system, the top management identifies the information requirements from different sub-systems and specifies other guidelines for integration of these information for effective support to decision making. The managers from different functional areas present the flow of information under individual sub-systems. The aspect of integration of information of different sub-systems is considered at the planning stage. Any modifications required at different points are pre-conceived at the beginning so that they are taken care from the design stage. This approach of implementation allows designing better structure of databases and ensures smooth flow of information at different levels of management of different functional areas.

8.6 Constraints in operating MIS

Following are the constraints in operation of an MIS :

- Non-availability of experts who can diagnose the requirement of organization and give desired direction
- Technical knowledge gap between management expert and computer expert
- Non-availability of right kind of cooperation of the employees
- High turnover of MIS expert
- Shortcoming in design leading to non-fulfillment of users' requirement
- Frequent changes in the information requirement by the users
- Non-standard requirements of management to handle special features of an organization
- Difficulty in quantifying the benefits of an MIS
- Heavy investment requirement for establishment of an MIS etc.

8.7 Limitations

Effectiveness of an MIS depends on its design, software, operating staff and users' consciousness level. The commonly observed gap between the system expert and the management experts sometimes becomes a bottleneck in designing an effective MIS. Apart from the above, the other limiting factors for MIS are :

- Effectiveness of MIS depends on efficiency of the management in using it and it is not a substitute of Management
- MIS only provides information and non-programmed decision making is in the hand of management
- Frequent changes in the information need of management reduces efficiency of MIS
- Success depends on quality of output and their effective use
- Effectiveness is greatly affected where culture of hoarding and not sharing information is there
- Problem of perception of utility
- Lack of proper training and awareness of both operation staff and the users on the use of MIS
- With the change in technology and business environment, management need of information changes thereby suggesting periodic review and continuous monitoring
- Cost Benefit assessment depends on many subjective assessments

8.8 Information Requirements of Management

Management information system is developed to provide the right kind of information for decision making. Information System, to be truly efficient, has to have interlink with different functional management. In no business, a single function operates in seclusion of other functional areas. Rather, they have close links. Unless different functions are seen in totality, strategic decision making for the organization as a whole can not be efficient.

Information Requirement depends on the following factors :

i) Operational functions

ii) Type of decision making

iii) Level of Management

8.8.1 Operational functions : The information generated in different functions is different and control requirements vary widely. For example, the requirement of information for decision making in production function will not be same as in case of financial function. The type of reports in different functional areas are given in para 8.10.

8.8.2 Type of decision making : Decision making type may be i) programmed decisions and ii) Non-programmed decisions.

Programmed decision making refers to those decision making process which are based on some standard set of procedure established by the management and according to scientific principle of management. In case of programmed decision making, supporting information sets and reports are standard, well defined and well structured. Naturally decision making process is simple and based on some guidelines. For example, stores ledger summary and material consumption reports may help in decision making on Inventory control.

Non-programmed decision making refers to those decision making process which does not go by any pre-determined set of guidelines. Normally this type of decision making takes place to handle special business situations with the help of experience, judgement and vision of the decision maker. In case of non-programmed decision making, information are unstructured and external environmental information is a must along with internal information sets. For example, for decision on business policy many non-standard information like technology change, competitors market share etc is required apart from internal information of sales of different products.

8.8.3 Level of management.

Information requirement varies with the level of management and purpose. The levels of management in the order of hierarchy are Top Management, Middle Management and Operational Management. The activities of different levels of management are given below :

Top Management **:** Top management is concerned with strategic decisions like diversification, technology acquisition, new market exploration, strategic business alliance, takeover, merger etc.

Middle Level **:** Middle level management is generally involved tactical decision making with the help of performance analysis, budget variance analysis, devising better productivity mechanism and control etc.

Operational Management **:** Operational Management staff are mainly involved in scheduling the activities, keeping track of progress of day-to-day operations and decisions of well structured problems etc.

The characteristics of information naturally varies depending on the functions of different levels of management. They are as given below:

Contents of Reports based on level of management:

Characteristics Information	**Top Management**	**Middle Management**	**Operational Management**
Focus of Planning & Management	Strategic Planning	Resource Management	Day - to - day activities
Boundary	Internal & External	Internal	Internal
Volume	Summary with analysis	Report of Variances	Reports of detailed activities
Integration among functional areas	Highly integrated	Moderately integrated	Restricted to functional area
Comparison with time frame	1 to 5 years	Previous year or month to month	Day - to - day
Support to decision making	Relatively Unstructured problems	Moderately structured problems	Structured problems

Level	**Information type**	**Report contents**
Top	Strategic information which are relatively unstructured and complex. Example : • Strategic decision making on production planning, new product, marketing, sales promotion etc. • Planning and Control of different activities of the organization as a whole • Financial Decision making – fund management or resource mobilization • Business policy decision	• Summary Results • Comparative figures • Possible Analytical presentation • Guideline for alternative options
Middle	Control information which are moderately structured and less complex . Example : • Tactical Planning • Control information for resource use and results like weekly sales of different products • Reasons of variances, if any	• Actual performance summary and variance analysis • Reports on exceptions

Level	Information type	Report contents
Opera-ting	Supervisory information which are highly structured and simple. Example : • Control on day to day activities like production, sales, purchases, idle time etc • Scheduling the activities	• Detailed reports • Operational results • Maintenance Report

8.9 Information need for Strategic Decision making

The primary objective of MIS to derive comprehensive information for effective decision making. The innovations of Information Technology is to reduce time for acquiring, processing and analyzing data to provide real time information. Today, business intelligence means accumulation of relevant market related real time information. The success of an MIS depends on the evolving right kind of flow of information for business strategic planning in an organization.

Strategic Information System is to provide best information flow to feed the management in the decision making process to sustain organization's competitive advantage. Information System with the power of information technology which ensures high speed communication can provide the best support to build decision making models. The Information System will help the organization in the following ways :

- Re-engineering the business process with fast review the results
- Building Competitive Intelligence through monitoring competitors' performance
- Capturing Market Information on new technology and products
- Market Trend analysis
- Designing products with the help of CAD tools

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- Designing products with the help of CAD tools

Types of information are given below.

Critical Success Factors :

- Cost Structure
- Product quality and innovations

- Customers' profile
- Customers Services
- Customers' satisfaction level
- Management development programmes
- Change management and flexibility etc.

External Information set

- Demographic
- Economic
- Technological
- Market measures
- Profit measures
- Industry benchmarks
- Competitors performance etc.

8.10 Different types of Reports

Depending on the level of management, different functional areas will require the following information:

8.10.1. Personnel Management

Top-level (Strategic information)

- Skill information (No of persons in a specialized area with Experience)
- Long term human resources requirement
- Policies on human resources development etc.

Middle Level (tactical information)

- Deployment pattern in different departments
- Personnel Deployment policy
- Performance Appraisal etc.

Operational Level (Operational information)

- Performance
- Leave / absentism
- Punctuality etc.

8.10.2 Production Management

Top-level (Strategic information)

- Policy on production – priority of different products etc.

- Yearly and monthly comparative results on production of different items
- Information on new technology
- Information on capacity utilization

Middle Level (tactical information)

- Actual performance with target
- Variance and their causes
- Breakdown and maintenance information

Operational Level (Operational information)

- Performance details
- Preventive maintenance schedule
- Machine performance etc.

8.10.3. Sales Management

Top-level (Strategic information)

- Information on new product or new market
- Information on market share
- Analysis of competitors strategy
- Sales growth or fall

Middle Level (tactical information)

- Actual sales – product wise with targets
- Sales Variance and their causes
- Performance of different sales offices

Operational Level (operational information)

- Sales details – branch wise product wise
- Individuals sales personnel performance
- Sales expenses details

8.11 Management Decision making

Today, the managers need information support for decision making. The business activities have become more complex and competition has become more acute. For survival, the decision making process must be accurate and at right time. For this, information base for decision making plays a great role. Development in Information Technology have created a new era in management decision making process. The decision making has become increasingly difficult due to following change in the business environment :

- Increase in the number of alternatives to be evaluated

- Increase in risk in business
- Complex decision making environment
- Time pressure
- High cost of making wrong decisions

8.12 Components of Business Information System

Business Information System comprises of :

i) Transaction Processing System

ii) Management Information System

iii) Expert System

iv) Decision Support System

v) Executive Information System

8.12.1 Transaction Processing System

Transaction processing refers to the processing of information relating to monetary transactions in the business activities like purchase, sale, payment, receipts etc. It is a computer based processing for different functional areas to generate all required reports for day-to-day use in the organization. The transaction processing system may be disintegrated or integrated. In case disintegrated transaction processing, data are collected from respective functional areas and processed and reports are generated for their use. In case of integrated transaction processing system, an application system which has capability of integrating all functional areas (say, ERP system), transaction processing are interlinked with all data from different system and the reports reflect the impact of integrated information.

Transaction processing may also be in batch mode or may follow on-line or distributed data processing system. Example of transaction processing in an organization :

- Payroll
- Accounts Receivable
- Bank Reconciliation
- Purchase Order Processing
- Sales Order Processing
- Inventory Control
- Job Costing etc.

8.12.2 On-line Transaction Processing (OLTP)

On-line transaction processing is carried in a client/server system. In todays competitive environment, information at right time plays a great role in controlling costs of various resources and providing best possible services to the customers. In other words, business environment has been characterized by growing competition, shrinking cycle time and accelerating pace of technological innovations and companies have to focus on better information management. Better information means right information at right time. OLTP are being adopted in wider scale to have the following advantages :

- It can serve multiple users at a point of time
- Technology serves the facilities to collect information from multi-locations
- High flexibility in information processing etc.

In case of Sales and Distribution System in an organization where transactions take place at different locations on-line transaction processing is followed to carry out the following basic functions :

- Inquiry handling
- Quotation preparation
- Receiving Order from Customers
- Checking availability of materials / products
- Scheduling delivery
- Monitoring sales transactions
- Invoicing
- Managing Bills Receivables etc.

8.12.3 On-line Analytical Processing (OLAP)

An OLAP software does the analysis of information from data warehouse. The OLAP applications are widely scattered in divergent application area like Finance Management, Sales Analysis. The real test of an OLAP system is inefficient use of data from databases and computational capability of data to develop model establishing the relationship of various parameters. In fact, it provides the services of 'just-in-time' information.

Though OLAP software are found in widely divergent functional areas, they have three common key features which are :

- Multidimensional views of data
- High analytical ability
- 'Just-in-time' information delivery

Rarely a business model limited a fewer than three dimensions. The common dimensions in business environment are organization, line item, time, product, channel, place etc. OLAP system should have the ability to respond the queries from a manager within a specified time. The OLAP software must provide a rich tool kit of powerful capability of analytical ability.

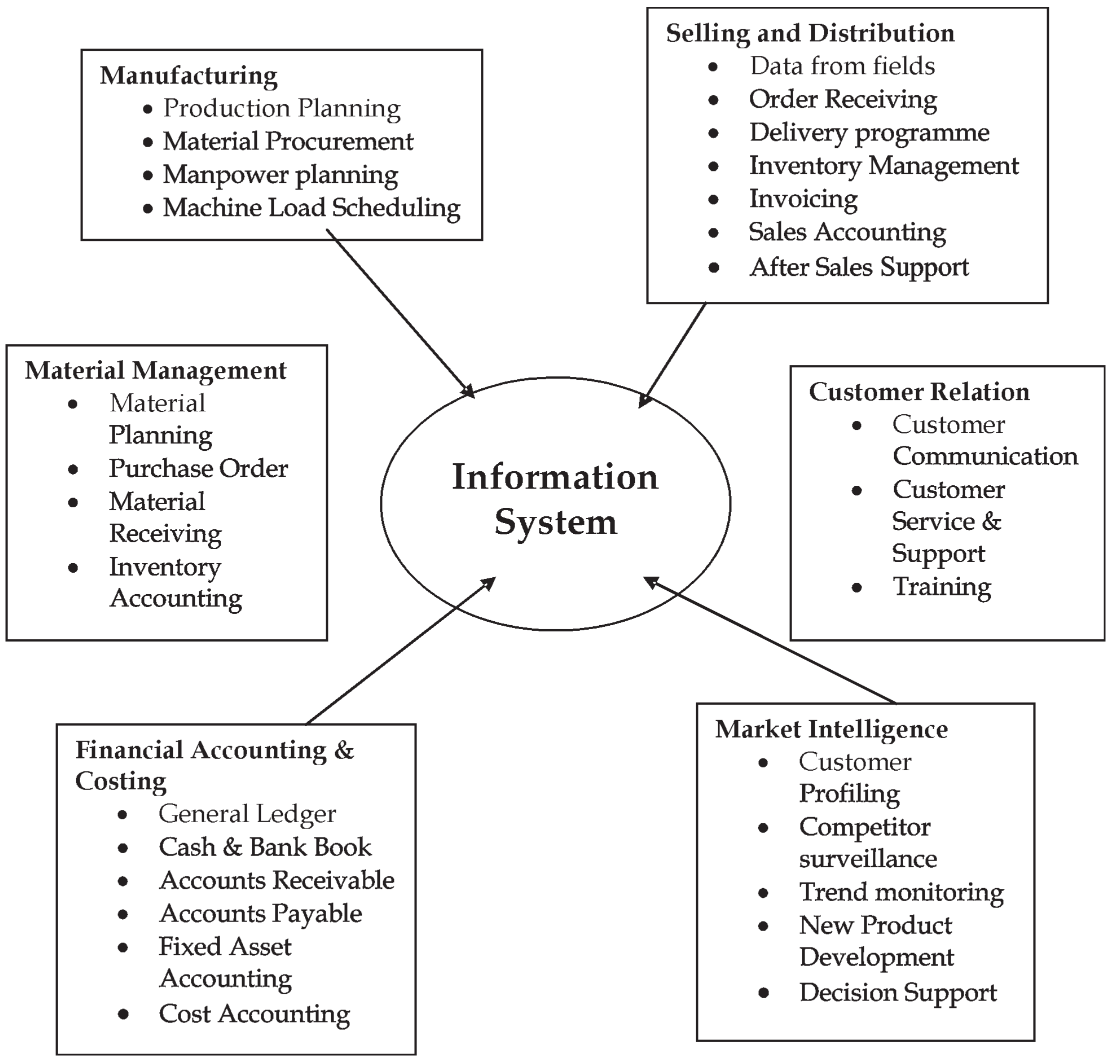
8.13 Need for Integration of Information Enterprise-wide

The conventional information systems aim at providing information related to different business functional areas to the respective managers for decision making. The evolution in information system suggest for integration of information of various functional areas enterprise wide for a comprehensive information set for more effective decision making. This is possible only by way of taking care of all transactions related data from different functional areas on-line and integrating them. Today an Enterprise Resource Planning (ERP) system in an organization grasps all business details in real time and integrate them to see activities of various functional areas together so that resources relocation is possible more meaningfully, rationally and cost-effectively.

Today, many organizations world-wide have clearly perceived the advantages of information integration. A good number of large and medium size organizations have implemented ERP system to derive the greater benefits of linking all the functional systems for effective use of information.

The following are the needs of integration of information :

- Information for various inter-related parameters provides clear picture
- Comprehensive review of business situation is possible
- Disjoint information may have serious gaps
- Redundancy of information is avoided by scientific linking
- Cross functional impacts in the business is assessed



8.14 Models used for representing the Information

Iconic scale model : It is physical replica of the system based on different scale from original. Iconic models may appear to scale in three dimensions - such as model of a production process, building, car or an aircraft.

Analytical model : It may be a model for a physical system but the model differs from actual system. Example – Map showing water, mountain etc. by different colours.

Mathematical Model : It represents a data set in the form of graph, picture or frictional diagram. It uses highly mathematical or statistical algorithm to interpret data of huge volume with ease. The algorithm varies depending on the complexity of analysis of data sets and the type of analysis.

8.15 Analysis of Information

1. Environment Analysis
   - Customers – need, choice, disposable income level
   - Suppliers – Range of product, pricing, after-sales service
   - Competition – pricing policy, quality etc.
   - Trade association – industry trend, technology
   - Government – control, taxes & duties
   - Market – population, demographics etc.
2. Product position analysis
   - Market share and growth
   - Product performance
   - Range of products and level of competition
   - Market trend
   - Technology and possibility of change
3. Cost Benefit Analysis
   - Payback period
   - Net Present Value
   - Internal rate of return
4. Business Planning
   - Operating performance analysis
   - Profitability analysis
   - Market Research
   - Product mix selection
   - Budgeting

8.16 Information requirement for Product Pricing Strategy

- History of change in price
- Demand for the product
- Graph showing demand and price & quality purchased
- Profitability of products
- Price of substitute products
- Price of similar products etc.

Sources of information

- In-house market database
- Industry statistics
- Market research information
- Feedback from customers
- Trade journals

8.17 Executive Information System

An Executive Information System (EIS) is special type MIS meant for top management of an organization. In other words, it is a Decision Support System (DSS) for Executives. Executive decisions are of three types – strategic planning, tactical planning and 'fire-fighting'.

According to CIMA –

An Executive Information System (EIS) is a set of procedure designed to allow senior managers to gather and evaluate information relating to the organization and its environment.

Naturally, the EIS takes care the requirement of information depending upon the type of decisions taken at different levels of managers in an organization. In fact, EIS acts as a tool specially designed for different executives to feed their information need in useful formats. A manager can navigate a particular format with some amount of computer skill. The EIS is not only limited to internal data source rather facilities to easy access to common sources of external data is also arranged.

Following are the special features of an EIS :

- It a specially designed tool to feed executives information need.
- It is an easy - to - use and screen based software .
- It provides the executives to facilities of on-line analysis tools like time series analysis, regression analysis etc.
- It is not limited to internal data only. Access to external sources of data is also provided.
- It provides the facilities to connect to internet

- Information is presented in summary format
- It is a comprehensive information system and work in conjunction with DSS.

For an Executive Information System, information requirement varies widely according to the requirement to understand the impact of different variables on the issue. For example, for decision of pricing of a product, information requirement may be summed up as follows :

- Recent history of price changes
- Demand for the product
- Graph showing the relationship between demand and price exhibited by recent results
- Effect of demand of changing price over time
- Prices of substitute products
- Price of similar products
- Cost of sales etc.

STUDY NOTE - 9

Enterprise Resource Management

9.1 Introduction

Enterprise Resource Planning has become a powerful tool in the h and s of management for effective use of resources and to improve efficiency of an enterprise. During 1970s Material Requirement Planning (MRP) was a fundamental concept of production management in manufacturing industries. In today's rapidly changing business environment every organization has to face new market, new st and ard for quality assurance, new competition, increasing customer expectations. As a result the business enterprises are in a constant need of reviewing and re-engineering their processes in order to survive and grow under competitive environment. With the advent of innovations in information technology, a concept of integrated approach embracing all functional areas have been evolved. This has led to development of ERP packages which were originally targeted at manufacturing industries and consisted mainly of functions like Sales Management, Production Management, Accounting and Financial Affairs. In the recent years this has been extended to all industries covering whole management functions like:

- Manufacturing
- Material Management
- Quality Management
- Sales and Distribution
- Logistic Management
- Maintenance Management
- Human Resources
- Finance
- Strategic and Operational Planning etc.

Some popularly known ERP packages:

- SAP AG
- Oracle Corporation
- Peoplesoft
- BaaN
- J D Adwards
- INTENTA (Sweden)
- QUAD
- Marshall (Developed by Ramco System, Chennai, India)
- SSA (System Software Associates, Inc., USA) etc.

ERP Package:

It is a software with the help of Database Management System integrating information related to all functional areas. Globally acceptance of ERP System is in great dem and . Industry analysts are forecasting growth rate of more than 30% in next five years. The reason for accepting ERP System replacing their old business system are as follows:

- Improved business performance through optimum resource utilization
- Reduction in manufacturing cycletime by integrated planning process
- Better support Customers in fast changing in market conditions
- Better Cost Control mechanism by way of accurate costing system
- Enhanced efficiency in control through feedback information and online access to accurate information
- Establishment of Decision Support System etc.

Three fundamental characteristics of an information system are accuracy, relevancy and timeliness. Today, time is a crucial parameter for good quality service to the market. In fact, there are interlinks among all the systems. A data in isolation does not give right direction in decision making. When the impact of the same can be seen in all activities in totality, the information becomes far more relevant. A well designed ERP package can provide these advantages.

9.2 Selection process of an ERP Package

There are many ERP packages available in the market. Analysing all the packages for choosing the right one is a time consuming process. Thus, it is better to limit the number of packages at the beginning for the purpose of evaluation. Looking at the product literature of the vendors, one can eliminate the packages that are not at all suitable. Normally this evaluation process is done by a Committee. What is required to be done is gap-analysis between the requirement of the company and capability of the package. Presentation or demo from the selective vendors will provide some direction towards choosing the best. Of course, cost of the package is also a key factor. Cost benefit analysis is also to be done.

The Common Criteria for selection for a package:

1. How best the package fits the requirement of the company
2. Provision for accommodating the changes in the system
3. Implementation and Post Implementation support from vendor
4. Reliability of Vendor
5. Change in Hardware and Skill requirement
6. Cost of the Package and Budget

Cost of ERP Implementation

A budget is required for implementation of an ERP package. It is not only the cost of ERP package but also there are many hidden costs that are to be considered. The following costs are to be considered:

1. ERP package cost.
2. Consultant cost.
3. Cost of Data conversion.

4. Cost of training.
5. Cost of testing.
6. Cost of Post-Implementation support.

Business Process Re-engineering and Implementation of ERP

According to Peter F. Drucker, “Re-engineering is new and it has to be done.” Business Process Re-Engineering (BPR) aims at performance improvement through dramatic change in organizational structure, skill development, change in technology and change in mindset of people. BPR is a process which explores the possibility of doing things in different ways to improve efficiency in the operation and it involves re-thinking, renovation, redesigning, retooling. In other words, it is an exercise towards transformation of an organization to dynamic change which involves lot of innovations in every activity.

Implementation of ERP involves replacement of all existing Information Systems. Thus at the beginning there is a need to change the traditional method of data gathering and analysis because data from different departments needs to be integrated. The question of performing in isolation vanishes. Developing linkage of data from different sources, correlating them and understanding the impact of an integrated system are the important processes involved in implementation of an ERP System. To device a system with holistic view of enterprise requires integration of isolated piecemeal Information Systems and facilitates seamless flow of information across departmental barriers. In other words, implementation of ERP Systems involves great change in information flow and reporting system. The success depends on support and co-operation of all users and managing the changes.

BPR exercise is essential for getting true benefit out of an implementation of ERP package. The main reason is to bring the changes in the physical system, data flow and mindset of the people to effectively utilize its capability of integrating information for the benefit of management decision making. BPR exercise may be divided into different phases as given below:

Phase I: Begin Organizational Change

- Understanding the current state of Organization
- Assess the need for changes
- To explain how to bring the changes
- To project the new dimension in the business
- To make a document on new organizational structure

Phase II: Bringing Re-engineering process

- Establish BPR Organizational structure
- Selection of people to be involved in BPR
- To fix the responsibilities of these people

Phase III: Identify BPR Operations

- To pinpoint the processes to be re-engineered
- To assess the potential changes

- To fix priorities of activities
- To draw performance matrix
- To establish business strategies
- To identify the potential barriers

Phase IV: Understanding the existing process

- To Develop the model of current process
- To understanding the technology currently in use
- To assess the present flow of information
- To identify the gaps in the flow of information

Phase V: Newly designed model

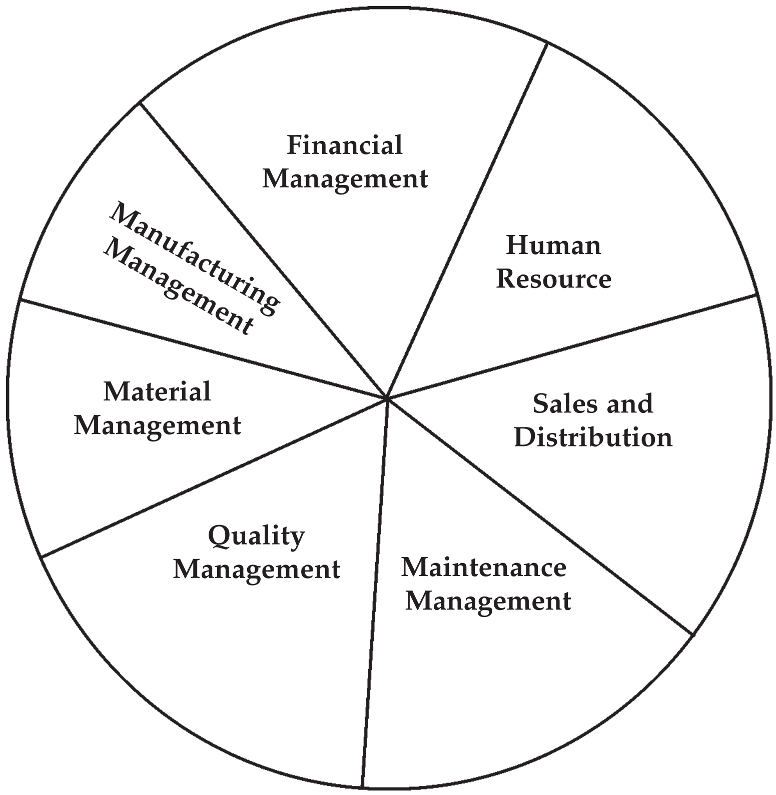
- To draw new work flow
- To define new process steps
- To describe the new information requirement
- To assess new technology requirement
- To assess skill requirement

Phase VI: Transformation

- To develop migration strategy
- To devise action plan
- To reallocate workforce
- To develop training curriculum
- To ensure smooth change over to new process

Business Modules in an ERP Package

All ERP packages contain a set of modules. These modules are related to different functional areas like Finance, Manufacturing and Production Planning, Materials Management, Selling and Distribution and so on. These modules in a business systems have close relationship. An ERP system takes care the flow of information from different modules and understanding the interactions among them. To avoid data redundancy, data generated from the activity centres are entered and the same data is considered by different modules of the system where the same is relevant for the purpose of understanding the impact of one the other. This is the basis of integration of information. This is the most important feature of an ERP system.



Module of ERP Package

1. **Finance Module:** Finance module in an ERP system will have the following sub-systems :
   - ***Financial Accounting***: General Ledger, Accounts Receivable, Accounts Payable, Fixed Assets Accounting etc.
   - ***Investment Management***: Investment Planning, Budgeting, Depreciation, Forecast, Simulation etc.
   - ***Controlling***: Overheads Cost Controlling, Activity Based Costing, Product Costing, Profitability Analysis etc.
   - ***Treasury***: Cash Management, Treasury Management, Market Risk Management, Funds Management etc.
2. **Manufacturing Module :** Manufacturing Module generally has the following sub-system:
   - Material and Capacity Planning
   - JIT/ Repetitive Manufacturing
   - Engineering Data Management
   - Cost Management
   - Quality Management
   - Configuration Management
   - Tooling etc.

3. **Human Resources Module:** Human Resource Module generally has the following sub-systems :
   - ***Personnel Management*** **–** HR Master data, personnel administration, Recruitment, Deployment, Transfer etc.
   - ***Organizational Management*** **–** Job Specification, Staffing Scheduling, Personnel cost planning etc.
   - ***Payroll Accounting*** **–** Salary Calculation, Income Tax Calculation, Accounting for Fringe Benefits
   - ***Time Management*** **–** Staff Planning, Work Scheduling, Time Recording, Absence recording etc.
4. **Material Management Module**: Material Management Module generally consists of the following sub-systems:
   - Material Procurement planning
   - Purchasing
   - Vendor Evaluation
   - Inventory Management
   - Material Inspection etc.
5. **Sales and Distribution Module:**
   - Master Data Management
   - Order Management
   - Warehouse Management
   - Shipping
   - Billing
   - Pricing
   - Sales Support
   - Transportation
   - Foreign Trade etc.

ERP Implementation Life cycle

ERP implementation project involves different phases which have definite activities as explained below:

1. ***Pre-evaluation screening*** **–** to search for perfect package which will be most suitable in terms of functional fit of the business process, skill set available and easiness to adopt.
2. ***Package evaluation*** **–** to understanding the performance of the business and do the cost benefit analysis.
3. ***Project Planning Phase*** **–** to make a tentative plan for implementation in terms of time, identification of person responsible for co-ordination of the implementation programmes, skill development and monitoring the progress.
4. ***Gap Analysis*** **–** to identify the gap between the existing system and future expectations from the ERP system so as to optimize the outcome from the implementation programme.

5. ***Re-engineering* –** to bring the necessary changes in the system in terms of physical system, hardware, mindset of the people, data flow and reporting.

6. ***Configuration* –** to install the necessary hardware, data base management system and configuration of the ERP system accordingly.

7. ***Testing* –** to test the system with test data set like entering data, validating them and generating reports for all modules and checking their correctness.

8. ***End user Training*** – to impart training to people from different functional areas who will be associated with operations and handling reports.

9. ***Going live* –** to finally switching over to new system with data migration, and running the system with live data of all functional areas.

10. ***Post – Implementation*** – to arrange for maintenance of the system in terms provision of technical expertise in cases of problems.

Implementation Methodology

The methodology of implementation of ERP system involves different activities like understanding the need for the system, benefits to be derived, people to be associated, need for their skill updates, database configuration etc. Generally, an ERP implementation can be divided into four phases:

1. Understanding the problem
2. Defining solutions
3. Undertaking technical work
4. Going live
5. Post implementation maintenance

1. ***Understanding the problem*:** This is the phase where in-depth analysis of business system is undertaken to understanding the need for an integrated system in handling data and how to improve the data flow towards better management reporting and effective decision making. The company goes for evaluation of different packages and selects the one which is the perfect fit to the requirement. In the evaluation process of the package the following parameters are taken into consideration:

   - Functional fit with company's business process
   - Degree of implementation among various modules
   - Flexibility
   - Technology requirement
   - Cost of the system (Systems, Training and Maintenance)
   - Time of implementation
   - Skill requirement
   - Technical support

2. ***Defining the solution*****:** This phase considers all the intricacies of the systems so as to take care of all those during the development process. The gaps in the present system, scope of improvement in the data flow and need for integration for better control are the most important three areas which are critically evaluated to arrive at a solution set. Finally, the outcome of the same is taken into consideration for software. This phase gives solution for data migration process, volume of data and database size, plan for implementation in terms of technical requirements and timeframe. In fact, in this phase, project team is built, project schedule is defined for all broad activities.

3. ***Undertaking Technical Work:*** In this phase, the activities are broken into details. The work involved in this phase are:

   - Procurement of hardware
   - Configuration of the system
   - Data migration
   - Developing and testing the interfaces
   - Developing the new procedure associated with the system
   - Testing the new system
   - Training the end-users

4. ***Going Live:*** In this phase, the system is to be finally implemented in new environment with real life data set and to the satisfaction of the end-users. In ERP systems, the integration of all the modules is the critical part. The end-users must understanding the sequence of operations, how one module interact with the others and what are the restrictions in operation in terms of priority so as to establish proper checks at all levels in the process. The co-ordination among project members for different modules is very essential for smooth and successful implementation.

   Post-implementation maintenance: Once the implementation is over, the services of vendor and the hired consultants will not be available. Trained in-house employees may have limited exposure to take care of all the problems just after implementation. Post implementation needs a different set of roles and skills to solve the problems in an integrated system. The training will never end. New functionality may be added which will invite different technical problems like enhancement of system, fresh configuration for added integration features. Thus, this is a very critical phase. To reap the full benefit of ERP system, there should be arrangement for continuous training of employees and periodical review on how to enhance the advantage from the system.

STUDY NOTE - 10

Information System Control

10.1.1 Risk in Information System:

Risk is the probability of happening something adverse. An information is vulnerable to many risk factors which are categorized below.

Risk Management is a process of assessing risk and reducing it to an acceptable level. Steps involved in it are:

- Understanding the sources and causes of risk.
- Collection of data related to risk to analyse their nature and frequency.
- Evaluation of magnitude of risk.
- Develop policy to minimize the risk.
- Develop methodology to prevent their occurrence.
- Implementation of the methodology.

10.1.2 Different Categories of Risk Factors:

1. Hardware
   - Damage by lightening, fire, earthquake etc
   - Failure of communication and network system
   - Power failure
   - Breakdown of computer system etc
2. Software
   - Errors in programs
   - Errors in operation
   - Weakness in control
   - Damage by computer virus etc
3. Database
   - Destruction of data-file
   - Loss in data integrity
   - Misuse of database etc
4. Input Data
   - Incorrect data
   - Damage of data file
   - Collusive fraud etc
5. Operational Risk
   - Failure of machine
   - Failure of software
   - Wrong operation etc

6. Others
   - Technological obsolescence
   - Fraud
   - Damage by disgruntled employees
   - Unauthorised access by hackers
   - Damage by natural disaster like fire, flood
   - Leakage of sensitive information etc

10.1.3 Developing Methodology to Minimize Risk

To create proper environment, to establish proper Control Mechanism and regular vigilance on the proper functioning of the established norms in the Information system are essential to reduce the risk. Standard Auditing Practices (SAP-6) emphasise the need for proper internal controls to check the probable hazards from outside.

Following provisions and environment are developed to check the occurrence of risk factors or to take care the eventuality in case of failure:

i) ***Documentation:*** Documentation on Policy, procedure and System Administration.

ii) ***Creation of congenial Environment:*** Care Environment free from hazards to minimize chance of damage of systems.

iii) ***Preventive Maintenance:*** Regular and timely preventive maintenance.

iv) ***Quality Management:*** Ensuring the quality of software at the development, testing and operational efficiency etc.

v) ***Security Management:*** Strict control on unauthorized access by password and different types of permissions to allow access to / operation of the system to different sets of operating staff.

vi) ***Recovery System:*** Regular back-up of data files to take care of damage or failure and parallel processing for real-time system.

vii) ***System Administration:*** Follow of strict code of system administration.

viii) ***Set of Routine Procedure:*** Keeping regular vigilance on probable damage options.

ix) ***Training:*** Training to improve the awareness of control among the employees.

x) ***Ethical Standard:*** Special care for maintenance ethical standard in the working environment etc.

10.2 Information System and Management Control

In an organisation it becomes the management responsibility to develop its information system to attain its objectives. Accordingly, it has to structure its organization of Information Systems. The basic objective of information system is to provide the required smooth flow of information for planning and control activities. To strengthening the internal control system, Standard Auditing Practices (SAP-1) suggest the following steps:

i) Framing policies and procedure for Effective Control.

ii) Establishment of sound organization structure with clearly defining responsibilities and authority for access to information, supervision and control on information System.

iii) Creation of better control environment through effective budgetary control system

iv) Ensuring smooth flow of information for effective control.

v) Regular Monitoring the internal control systems.

vi) Periodic review of control system.

10.2.1 Policies and Procedure for Effective Control:

Policy establishes the rule of procedure and boundaries for authority of individuals in action and decision making. Policy for Internal Control for Information System basically aims at fixing sequence of flow of data, taking measures for security of information, ensuring timely processing of data and generation of Information Reports and use of the same with definite objectives. Procedure will delineate the detailed steps to be followed for execution and check the deviations, if any. Policy will depict the guidelines on the following :

- Level of authority
- System of cross check
- Procedure of monitoring
- System of review of control system etc.

10.2.2 Creation of Proper Processing Environment

Creation for proper environment is essential for effective control system. The two important components there are of great importance-discipline and ethics. Unless these two are enforced no control system can be full proof. Control is done to see that the existing procedure is running smoothly and with comparison with some standard. Performance budget must be prepared honestly. If the budget is vague and sub-standard, all control measures are futile. Thus creation of environment with professional ethics must be taken care properly. Without proper environment, no amount of deviation from norms get properly checked. Internal Control system in Information system aims at :

- Data Security
- Preventive maintenance
- Proper resource management
- Timely data processing
- Cost of data processing etc.

10.2.3. Smooth Flow of Information:

Success of an information system depends on its timeliness and quality of report. The user should appreciate its utility of the information report. Utility of report is great when user is fully dependent on it. To ensure these two intergradient in flow of information, the following checks must be built in into the system:

- Documentation
- Well defined responsibility
- Clearly spelt-out duties of individuals in Information Systems department
- Preventive measures against failures
- Standardisation in the system
- Proper user manual
- Good training
- Regular check procedure etc.

10.2.4 Monitoring:

Regular supervision is a preventive measures for smooth functioning of the system established with an objective. This is extremely important in data processing. The fraud uses the loose ends in the system. In an tightly controlled environment, the chance of fraudulent activity or sabotage is greatly reduced. In data processing fraudulent activity or sabotage may cause great damage. Thus, regular supervision of machine, machine usage, input and output with proper records with signature of proper authority should be an in-build system in Data Processing Environment. Statistical records of deviations in flow may help to review the system.

10.2.5 Periodic Review

Periodic review of the control system is essential to assess the efficiency of the existing control system, their adequacy and change needed to match the change the environment and technological developments. Review report should be submitted to senior management and independent observer to have independent assessment of the justification of the suggestions under the review.

10.3 Controls in Information System

Now, application of computer in a business organization has become wide ranging. Sometimes it happens that the computer use in different application systems have started in different points of time and that too not in a planned manner. The problem becomes more when the approach is half-hearted and without satisfying the technical requirements.

With the hardware cost going down day by day, the online processing is gaining tremendous popularity in the data processing environment. Today, data base management system has brought the idea of data integration to reduce data redundancy and effective combination of information in reports to derive better decision making process. This development has brought the need of data control more seriously than before. A familiar expression is there – GOGO (garbage-in-garbage-out). Thus, control of both input and out put has become more than necessary to ensure correct reports, avoid chaos, to enhance effectiveness of computer based application system.

Controls in Information System mean the policy, procedure and system followed to ensure the desired objectives.

10.3.1 Organization Structure Control:

Each operational task must be well defined. Segregation of tasks and responsibility of execution of the each task should be assigned to definite group of personnel to fix accountability. Following tasks are to a assigned to a designated group of personnel as given below:

Task	Staff Responsible
System Development	Systems Analyst, Programmer
Computer Operation	Computer Operator
Database Administration	Database Administrator
Hardware Maintenance	Maintenance Engineer
Network Maintenance	Network Specialist
Data Security	Input/Output Control Staff

10.3.2 Control in Operation Environment

The control and monitoring on the following things essential to provide suitable environment for data processing :

- Proper earthing of electrical line.
- Provision of UPS to protect the system from abrupt failure.
- Maintenance of proper register for users.
- Cleaning by vacuum cleaning.
- Regular electrical maintenance.
- Diagram of Electrical/network cabling to be documented.
- Allowing use of only licenced version of software.
- Provision of Annual Maintenance of Systems etc.

10.3.3 Preventive Measures against Damage:

The Preventive control measures are to protect the system from accidental damage or intentional threat. These may be summarized as below:

- Proper security measures against theft and damage of hardware.
- Arrangement from disaster recovery.
- Proper back up system to prevent from accidental data loss.
- Routine check on unauthorized access to system.
- Prevention from damage of Operating System, Programs and data files by virus.

10.4 Controls in Processing Environment

Some controls during data processing is required to ensure that the data which will be processed are correct. For this purpose, input control, access control, process controls and output controls are necessary. Details of these controls are described. A summary of these control are given in the table below:

Category	**Control**	**Purpose**
Input Control	Input Coding	To ensure correct codification of data item. This is done validity checking of codes in the program.
	Record Count	To number every records to detect any missing records
	Hashing	Use of codes in place of name of person or party to avoid disclosure of confidential information.
	Batch Total	Putting manual total of a batch of records to match the same with computer batch total to avoid mistake in data entry.
	Authentication	To ensure authenticity of the input.
Access Control		This is done by the use of password or other restriction to allow access to data, file or devices.
Processing Control	Format Check	To check the validity of data size and data type in terms of alphabetic and numeric.
	Limit Check	To ensure correctness of figure by a check of logical limit of value of single transaction. For example, limit for a cash transaction may be Rs 5000.
	Control Total	Control total is generated by the computer during processing to allow checking with the input control total.
	Exception Report	To identify the input data which are logically invalid.
Output Control		To check the output control figures generated by machine with the corresponding input control figures.
Audit Trail		To follow the processing sequence of an input data with the help of Reference No. corresponding to a transaction. This is a checking process by the auditor with the help of test data whether a transaction is processed in the right sequence to reflect its impact correctly in the reports.

10.4.1 Input Control:

Input control is required to ensure correctness of data from source and their completeness and authorization. Errors in input data may be out of following reasons:

- Incorrect data out of clerical mistake.

- Wrong codification.
- Willful mistake for doing fraud.
- Mistake at the time of data entry etc.

Following are the checks must be followed to ensure accuracy in input:

- ***Pre-numbered Source Documents*** - Printed source documents with numbers are only documents allowed to prepare source documents to have adequate physical security on the document preparation and to prevent fraud.
- ***Input Authentication Check*** – to see whether input documents are authenticated by well defined official of user department.
- ***Batch Control*** – to validate the correctness of important mathematical information of a group of documents with its manual batch total and computer total.
- ***Check Digit*** – check digit is a redundant digit derived from some mathematical relation out of other digits of the code which is incorporated in the code itself to ensure correctness of code.
- Proper system of verification of data entered in the computer–off-line/on-line.
- ***Check List*** – detailed list of data entered with indication of logical errors or errors in codes.
- ***Parity Check*** – a system of adding an extra bit to each character in order to check the possibility of loss of bits during data transfer/transmission to media like tape.

10.4.2 Access Control:

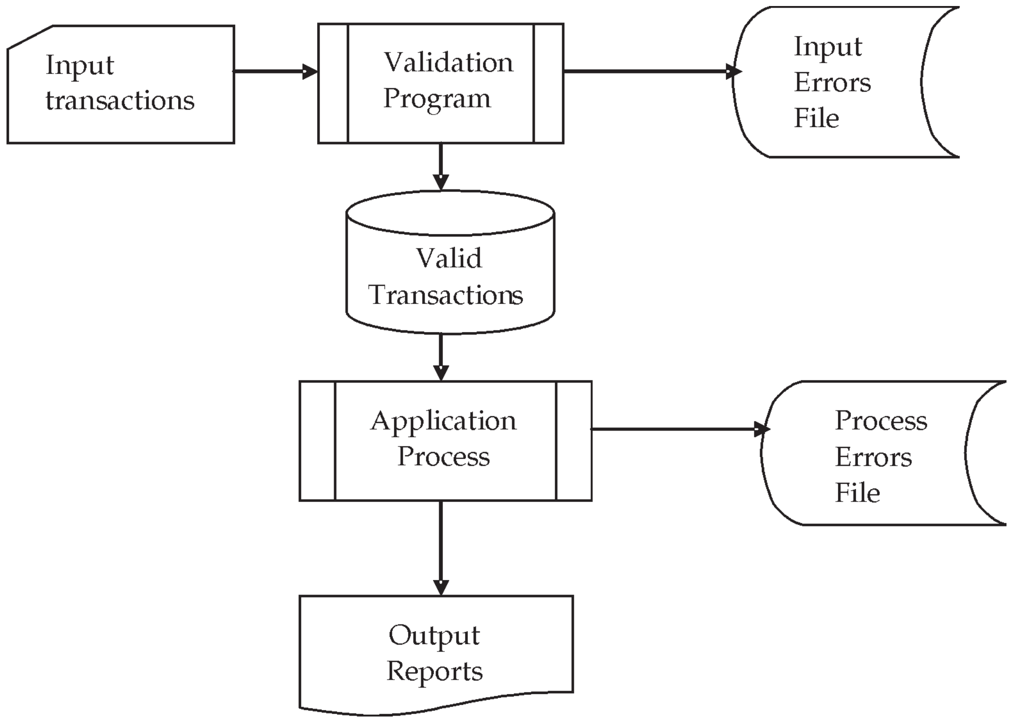
Access to computer should be restricted to authorized persons only to prevent fraud, damage and ensure better security of information and assets. For this purpose, a security policy and framework must be devised. The primary control for security purpose is access control. Access control is executed with the following checks :

- Permission to level of access to system depending on category of user.
- Periodic change of password should be made mandatory.
- Password of System Administrator should be kept in safe custody under sealed cover.
- Access restricted to only users presently working in the Department/Branch.
- Use of Standard Anti-virus software in all PC's.

10.4.3 Processing Control:

Processing controls means checking the logical errors of input data and ensuring validity of data according to the rules of source document preparation. They are :

- To check the validity of data size and data type in terms of alphabetic and numeric data
- To ensure correctness of figure by a check of logical limit of value of single transaction. For example, limit for a cash transaction may be Rs 5000.
- Control total is generated by the computer during processing to allow checking with the input control total.
- To identify the input data which are logically invalid



10.4.4 Output Controls:

Output Controls are to ensure that the reports generated for the users are correct and the output files created or/and database updated are correct and consistent. Other controls are:

- Checking the output reports with batch control totals.
- Thorough checking of correctness of output reports.
- Distribution of output to the authorized users only.
- Back up of output files at regular intervals.

10.5 Documentation Control

- All manuals — System Manual, User Manu both for hardware and software must be kept in the department.
- Logbook must be maintained for processing records and generation of reports with signature of authorized person.
- Records of usage, down time, maintenance calls and maintenance service must be maintained.

10.6 Computer Fraud

Computer fraud is an illegal action with the help of computer technology to make financial gain, to have unauthorized access to private information of others, to damage software/data etc.

The computer frauds have become a very sensible issue because of the following situation:

- Wide interconnectivity among the machines through network thereby making information system more vulnerable.
- Internet and e-commerce have increased the risk of hacking.
- Growth of e-cash transactions will induce more frequent attempt for interception.
- Common tendency for piracy of software.
- Strategic damage out of unauthorized access by competitor/enemy to confidential information.

Some common computer frauds:

Technique	**Description**
Hacking	Unauthorized access to software and information.
Cracker	Unauthorized access to machine with intention of damage to data, software etc.
Password cracking	To have an access to systems resources by decrypting password.
Software piracy	Copying software for illegal use without paying due price.
Virus	Use of software to damage set of software/data files in the machine.
Trap door	Access to system by passing normal systems control.
Super-zapping	Access to special system programs bypassing normal systems control.

Measures for detection of fraud:

- Proper audit at regular intervals on control measures.
- Use of expert software to provide advance alert signal etc.

Measures for prevention of damage out of fraud:

- Proper security measures.
- Proper audit at regular intervals on control measures.
- Disk imaging.
- Keeping regular backup of important files/databases.
- Train employees in measures against fraud prevention.
- Identify and manage disgruntled employees.
- Punishment to unethical activities.
- Use of only licenced version of software etc.

10.7 Security of Information System

Security of information system refers to protection of databases, output reports and assets from damage. Damage may be from theft, sabotage, natural disaster, fraud etc. The security of information system means protecting the confidentiality, availability and integrity of information. According to IFAC guidelines –

information security is for protecting the interest of those relying on information, and the systems and communications that deliver the information, from harm resulting from failures of availability, confidentiality and integrity.

In today's scene of global competition, the information system for an business organization is the pivotal point on which business run. Security has become of a big concern for wide scale of network use, development of innovative techniques of frauds and damage by unauthorized access. The damage are of following types:

- Leakage of sensitive information by unauthorized access.
- Misuse of system.
- Fraud by using loose controls or with the aid of technology maneuvering.
- Theft or physical damage of computer, software etc.

Objectives of Information Security:

- Assignment of responsibility for maintenance of data.
- Standardization of system of access to prevent damage by unauthorized access.
- Safeguard against threat of loss or damage of hardware, data and software.
- Arousing awareness on risk among the staff.
- Protection from chaotic situation out of system failure etc.

Role of Security Administrator:

The threats of damage or loss of hardware, data and software by frauds have evolved a new responsibility in information system environment, that is to ensure the safety to information system. His responsibilities are:

- Framing information system security policy.
- Devising measures to ensure safeguard from possible threats.
- Train the staff for effective action.
- Implementation of security system.
- Monitor the security measures.
- Developing action plan for emergency recovery.

The security measures have become prime important to minimize the risk in safeguarding the loss of assets and information of the organization. Following measures are taken to safeguard Computer equipment and databases:

- Arrangement of physical security
- Access Control
- Insurance against damage

10.7.1 Physical Security

The following physical restrictions to unauthorized access are termed as physical security:

- Door
- Machine Lock
- Guard
- Floppy disk access lock etc.

10.7.2 Access Security with Checks in Computer System:

- Password
- Biometric security
- Firewall
- Database security
- Network security

10.7.2.1 Password Security:

This security measure is to control access to computer or system with the help of password. The system preserves the password in encrypted manner. Password is a confidential key to a person and in normal situation no person is in a position to have the password. It is an easy and simple system of security control measures to prevent access to a computer/software.

10.7.2.2 Biometric Security:

Biometrics is a mechanism of defining user profile based on physical parameters and behaviour. Some of the biometric characteristics are signature, voice, facial scan etc. Authentication with the help of biometric characteristics needs special hardware and software for image processing. The identifications/ authentications are stored in databases which are checked at the time of allowing access.

10.7.2.3 Firewall:

Firewalls offer an effective system to protect access by unauthorized user from outside. The main feature of firewall is packet-filtering router so that vital information does not pass to any unauthorized intruder, even if he manages get access to the network system. It is a system of security in the network with the help of hardware and software. A software checks all incoming and outgoing internet traffics. The firewall routes the massages to a safe area to avoid any danger in the in forward transmission of messages. The screening by firewall software may delay the transmission process but ensures proper security.

Limitations of Firewall

- Passing on information by internal employees through internet can not be checked.
- Firewall can not protect the system from virus.

10.7.3.4 Database Security:

Access to database is controlled based on the degree of sensitivity of the data in the database. Users are categorized on the basis of permission to be given for access to different levels of data on the basis of sensitivity and control is made by the database administrator.

10.7.3.5 Network Security:

Access to network is controlled by password, firewall security measures. Network protocol also takes care of security aspect for access to network. Apart from these, Terminal Access Controller Access Control System (TACACS) and Remote Authentication Dial In User Service (RADIUS) also have remote authentication mechanism to control access.

10.7.3.6 Insurance:

Proper Insurance coverage of assets and software is essential to protect the financial loss to the company . It may cover damage/loss to

- Computer
- Database
- Software
- Media etc

10.8 Disaster Recovery

10.8.1 Disaster:

Disaster means sudden great misfortunate happening which can not be prevented. Disaster may be of two types – i) Natural like flood, earthquake, hurricane damage etc. ii) Technological like failure of computer, electrical fire etc.

10.8.2 Disaster Recover Plan:

The damage under disaster is generally enormous. The question of recovery in case of disaster comes from data. Data may be categorized as critical, vital, sensitive and non-critical. Recover plan may be devised accordingly to given priority of recovery of data of different importance.

Emergency Action : In the first stage the notification of damage is to be given to the appropriate agency/authority like fire service, police, insurance company etc. Then following action may be taken depending in the situation to save personnel, equipment, data etc like:

- sounding alarm bell
- use of fire extinguisher
- saving the back-up of software, data etc.

Recovery Action: There needs an advanced planning for recovery of data under disaster. Generally, the disaster recovery planning is done by a Recovery Committee and execution of recovery programmes is done under its supervision and control. These are:

- Backup Application software and backup of databases at a regular interval to be preserved in some other location.
- Mirror imaging of disk.
- Selection of alternative computer system.
- Restoration of application software and databases in the new computer system.
- Critical evaluation of performance of the application software.
- Assessment of loss of databases.
- Plan for recovery of data loss etc.

STUDY NOTE - 11

Information System Audit

11.1 Objective

An organisation should control and audit its computer based information system. Otherwise, the costs of errors and irregularities that may happen in these systems may prove to be unaffordable. Uncontrolled use of computers can have an adverse effect on society. For example, inaccurate information may cause a misallocation of resources within the economy and there may be fraudulent practices causing harm to the society – mainly to the low income group general public. Because computers play a vital role in processing data and also in the decision - making process, it is imperative that their uses must be controlled. The reasons for such measures are:

» there may be adverse consequences as a result of losing the data resources,

» misallocation of resources because of incorrect decision based on incorrect data,

» computer systems being uncontrolled, there is possibility of computer abuse,

» the high value of computer hardware, software, and personnel,

» high costs of computer error,

» the need to maintain the privacy of individuals persons, and

» the need to control the evolutionary use of computers.

11.2 Definition

The information systems auditing is the process of collecting and evaluating evidence to determine whether a computer system safeguards assets, maintains data integrity, allows organisational goals to be achieved effectively, and uses resources efficiently.

Thus the information systems auditing supports the following objectives:

- safeguarding of assets which include hardware, software, people i.e. knowledge, data files, system documentation etc.
- data integrity i.e. completeness, soundness, purity and veracity,
- system effectiveness i.e. it has knowledge of user needs and facilitates decision making process in the organisation,
- system efficiency i.e. use of minimum resources to fulfil the desired objectives, and
- statutory compliance i.e. rules, regulations, or conditions to be complied with under various Acts, Laws, Regulations etc.

11.3 Internal Control

The basic objectives of information system auditing are asset safeguarding, data integrity, system effectiveness and system efficiency. But all these objectives cannot be achieved unless there is a system of internal control imposed by the management. While the conventional approach towards internal control do not change under a computerized environment, but the implementation of the control system may have to be adapted to the functioning of the computer system. Major areas of internal control system are discussed hereunder:

- ***Separation of duties and responsibilities*****:** In a conventional system, responsibility is separated for each of the aspects of initiating transactions, recording transactions and maintaining custody of assets in order to prevent or detect errors and irregularities. In a computerized system, this may not be possible in a straight manner. Duty or authority to change program/data may be separated from the point of view of control.

- ***Delegation of authority and responsibility*****:** This is an essential control both under manual and computer system. In a multi-user database management system, the control problem regarding integrity of data and redundancy of data is minimized. Where more users have authority for developing, modifying, operating and maintaining their application systems instead of by computer professionals, there may be some difficulty in exercising control.

- ***Specialist/trained personnel*****:** If the organisation maintains professionally qualified specialist personnel e.g. System Analyst, Database Administrator, Application Programmer, Computer Operator etc., the control aspect becomes easier to be exercised. Many companies do not maintain such specialists because of high cost of retention. In that case competent and properly trained personnel should be deployed, as the power vested in the personnel responsible for computer system generally far exceeds the power exercised by the personnel engaged in a manual system.

- ***Authorisation system*****:** Authorisation may be of two types viz. general authorisation (e.g. authority to sell goods at a price as per approved price list) and specific authorisation (purchase proposal requires vetting of the appropriate tender committee depending on type of tender/tender value). While evaluating the adequacy of authorisation procedures, auditor should examine both the work of the related person and the specification of the program processing.

» ***Audit and management trail*****:** Computer system should be so designed as to provide audit or management trail by maintaining a record of all events and providing access to any record. Adequate access control and logging facilities will ensure preservation of an accurate and complete audit trail.

» ***Physical control of assets and records*****:** In a computer system, because of concentration of information system assets and records, risk of losses due to computer abuse or a disaster increases. Therefore, backup or recovery procedure should be subjected to audit.

» ***Adequacy of management control*****:** Under a client-server system and communication network in use, operational staff and managerial personnel may be separated by distance and control is to be exercised remotely. Therefore, parameter of control should be in-built in the computer system to enable adequate control which otherwise would have been exercised through physical supervision, observation and inquiry under a manual system.

» ***Performance control*****:** The controls incorporated in the program development, modification, operation and maintenance should undergo evaluation to ensure veracity of program code.

» ***Comparing recorded data with assets*****:** The recorded data and the assets represented by the data should be compared periodically to ascertain any incompleteness or inaccuracies in the data.

11.4 Audit Planning

Managing information system audit function is based on the five traditional management functions viz. planning, organising, staffing, leading and controlling. Furthermore, the impact of professionalism and changing technology should also be taken into account. In view of outsourcing trends in industries, the management of an internal audit group as well as an external audit group should be kept in view depending on circumstances.

11.4.1 Planning Function

In managing the information system audit function, two types of audit plans are envisaged :–

- Long - run plans
- Short - run plans

The objectives for long run planning are to:

- formulate overall direction for the function,
- make provision for adequate resources to discharge the responsibilities effectively and efficiently.

The determination of the former objective will have its consequent effect on the latter objective.

Long run planning of the audit function depends on examining the criticality or relative importance placed by the organisation on the four goals viz. asset safeguarding, data integrity, system effectiveness and system efficiency. Although the four goals are existent in all organisations but their relative weightage cannot be same e.g. asset safeguarding and data integrity in a stock exchange cannot be of same importance as in a consultancy firm. The nature of and extent of audit planning are also guided by the importance of the existing information system vis-à-vis the future information system in the organisation. The extent of long run planning needs increases with the increase of the importance of future information system. Extensive short - run audit planning is necessary if importance of current information system is high.

The objective for short - run planning is to undertake a risk management program to enable systematic evaluation of exposures faced by the organisation and reduction of such exposures to an acceptable level.

Risk management should be proactive rather than reactive.

A risk management program enables to identify the area for more detailed work associated with audit or a security program and overall control of the level of audit risk associated with the organisation. It would then be possible to determine the resources required to conduct the program of audit.

11.5 Documentation

The documentation required to ensure functioning of information system in an organisation are of the following types:

- strategic and operation plans
- complete system and software documentation
- manuals
- memoranda, books and journals

A part of the documentation may be in magnetic form e.g. where systems are developed with the help of CASE (computer aided systems engineering), the data-flow diagrams, entity-relationship diagrams etc. may be in machine-readable form, some documentation may be on optical disk (CD-ROM).

Effective management of information system documentation may be difficult for the following reasons:

- responsibility for documentation may be dispersed throughout the organisation (e.g. it may be centralised to support mainframe/minicomputer system but may be vested in all users of microcomputers).
- documentation may exist in various forms at various locations viz. in hard-copy form, in magnetic form, in microform or in some combination of forms.
- distribution of documentation to many users.
- ensuring documentation to be up-to-date at all locations and controlling access to authorised users only.
- maintaining adequate backup for documentation.
- managing inventory of acquired software and licensed software.

Depending on the importance and span of control of documentation, it may be necessary to maintain a program library under a documentation librarian to ensure –

- secure storing of documentation
- access only to authorised personnel
- documentation to be up-to-date
- adequate backup
- managing of inventory of acquired/licensed software to prevent loss, illegal copying, non-compliance of terms and conditions of licensing agreement, unnecessary purchase of additional copies of software, improper maintenance of backup. Help of report generating utility or software may also be taken for review.

Auditors by way of querying, observation and reviewing documentation should evaluate the efficacy of the system. Auditors should be satisfied that documentation is maintained securely and it can be accessed only by authorised persons. The objective is to prevent improper use of or modification to software and ensure availability of documentation for maintenance of the software.

11.6 Testing

The purpose of testing is to determine whether the developed or acquired software achieves its specified requirements. During this process, program design errors or program coding errors may arise. Even insufficiency or inaccurate specifications may be detected. Testing can however detect only presence of errors and not absence of errors. Designing of tests is very important for elimination of errors. It involves seven steps as under:–

1. Selection of the boundaries of the test – whether a particular module or several modules or entire program.
2. Determination of the goals of the test – to identify unauthorised/incomplete/inaccurate ineffective/ inefficient code.

3. Selection of testing approach – black-box or white-box.
4. Development of test data to accomplish the goal of the test.
5. Conducting the test through execution of test data or simulation of program execution pattern.
6. Evaluation of the test results against expected results and determination of the nature of discrepancies.
7. Documentation of the testing process.

Auditors should pay particular attention to the testing phase of the program development life cycle. A high quality testing undermines how well other phases are performed. In a software project, testing consumes considerable portion of development and implementation resources.

11.6.1 Levels of Testing

There are three levels of testing that can be conducted for testing of a program viz. unit testing, integration testing and whole-of-program testing.

11.6.1.1 Unit Testing

Unit testing refers to evaluating individual modules within a program. It is applicable for large programs in which each module constitutes substantive part of work, no matter whether the program is developed in-house or acquired. In the case of purchase of off-the-shelf program, this may not be applied.

Unit testing can be of two types viz. static analysis test and dynamic analysis test.

Static analysis test refers to evaluation of the quality of a module by examining the source code in the following manner:

Type of test	**Detailment**
Desk checking	It is performed by the programmer who coded the module or by someone else by examining the module's code for detection of syntax errors/logic errors/deviation from standards/fraudulent code.
Structured Walk Through	The programmer who designed and coded the module leads other programmers through the module to review the process for detecting errors and irregularities.
Design and code inspection	A special review team led by a trained moderator to review the code of the program module in a formal manner. Documentation is maintained e.g. checklists, results in preprinted forms, follow-up procedures to ensure rectification of errors and irregularities etc.

A dynamic analysis test can be of two types:

Type of test	**Detailment**
Blackbox test	Test cases are designed on the basis of requirements specification for the module and then executed to determine deviations from requirements. Internal logic of a module is not examined neither excesses to the specified requirements are determined.

Type of test	Detailment
White-box test	After the internal logic of a module has been examined, test cases are designed on the internal working of the module to traverse the different execution paths built into a program.

Auditors should evaluate how well the unit testing was conducted. They may observe performing of static and dynamic analysis by choosing a sample of test documentation.

11.6.1.2 Integration Testing

Integration testing refers to evaluation of groups of program modules to determine whether:

» interfaces are working properly,

» specified requirements are met,

» there is any degeneration under high workloads, and

» processing is carried out efficiently

There may be two different strategies viz. big-bang testing where all inter-module dependencies are tested together and incremental testing where subset of modules are tested in an iterative manner to reach the total group of program modules.

There may be three types of integration testing approach:

Type of test	Detailment
Top–down test	Top level modules are tested first by simulating lower-level dummy modules to confirm the working of the interface correctly.
Bottom-up test	Bottom level modules are tested first by simulating higher-level dummy modules to confirm correctness of the working of the interface.
Hybrid test	It is a combination of top-down and bottom-up test. This is also known as sandwich testing.

Auditor should gather evidence of integration testing and check whether systematic approach was adopted and execution was carried out properly.

11.6.1.3 Whole-of-program Testing

Whole-of-program testing refers to test of the program in total to determine whether it meets the requirement and also evaluate the quality of the program.

Four types of tests are envisaged as under —

Type of test	Detailment
Function test	Whether the integrated program meets the requirement. The test is carried out by the programmers responsible for development.

Type of test	Detailment
Performance test	Whether performance criteria are fulfilled e.g. security, response time, throughput etc. The test is carried out by the programmers responsible for development of the program.
Acceptance test	Carried out by the end users. The test comprises both function test and performance test.
Installation test	Performed in the operational environment i.e. on the machine to be used for operational purpose.

While unit testing and integration testing may not be applied for smaller programs or off-the-shelf programs, whole-of-program test is applicable for all types of programs and of all sizes, bigger or small. Further, whole-of-program test may be carried out by the information system professionals or the end users or by anyone in the organisation responsible for development or implementation or acquisition of software. An auditor should gather information and satisfy himself that the whole-of-program testing was designed and executed properly.

11.7 Outsourcing

Outsourcing may be defined as the use of parties, external to the organisation, to provide goods or services to the organisation. Outsourcing in today's economic environment is considered as an important means of improving an organisation's competitiveness and profitability. By outsourcing an organisation can pay more attention to its core competitiveness and take advantage of other organisation's core competencies.

Any organisational function may be a point of consideration for outsourcing e.g. legal services, security, any manufacturing process, supply of components for the products, and even the information system itself.

The reasons for outsourcing of information system function are:

1. exercising greater control over the information system function if it is outsourced e.g. vendors being more responsive to user needs, sharing economies of scale achieved by the vendor and restricted consumption of information system resources which are no longer free.
2. Innovative approach because of access to new technology and expertise expected from the vendor.

There is some preparatory work before a decision on outsourcing of information system services can be taken. Such work is of the following nature:

1. It should be determined what part of information system activities can be outsourced, what are strategic to the organisation, and whether suitable (expert, dependable, financially viable and reliable) vendors exist.
2. Terms and conditions of the contract including termination clause for outsourcing should be determined incorporating scope of work, audit rights, performance criteria, responsibilities etc.
3. Monitoring compliance with the terms and conditions.
4. Impact on the organisation.
5. Procedures for outsourcing disaster recovery control.

11.8 Internal Auditors vs. External Auditors

There is a controversy on the question whether the information system auditors should participate during the system development process. Reasons for prevention of systems development deficiencies at the outset are weighed against the reasons for independence of the auditors to have review during ex post audit for betterment. Three types of audit can be envisaged in respect of system development process:

1. Concurrent audit as members of the system development team.
2. Post implementation audit.
3. General audit for evaluation of overall controls, system effectiveness and efficiency.

External audit is generally considered in the area of general audit rather than concurrent or post implementation audit. However, deployment of external auditor may be considered for concurrent and/ or post implementation audit if it is opined that their involvement and expertise will be cost-effective and bring about quality in the process. Both internal and external auditors may have preference to preserve their independence. If they participate as member of the system development team, they should not conduct ex post review, which, in effect, is evaluating their own work.

11.9 Audit Charter

There is a need for an audit charter for properly organising the information system audit function within an organisation. An audit charter covers legitimacy and role of the internal audit function inclusive of information system audit function and deals with three issues viz.

1. Place of audit function within the organisation and its role in contributing towards fulfilment of organisational goals.
2. Authority of the audit function to gain access to records, facilities and personnel including Board of Director's audit committee or to the Board itself.
3. Responsibility of the audit function to advice the management about the quality of attainment of the four objectives viz. asset safeguarding, data integrity, system effectiveness and system efficiency.

The rights and responsibilities of both the internal audit function and the information systems audit function within an organisation should be clearly defined to prevent disputes over the issue and ensure effectiveness and efficiency of the audit function. It is also to be determined whether information system audit should have line function or staff function after considering the arguments for each strategy in the overall organisational perspective. Another issue concerns about centralisation as against decentralisation. This issue is to be dealt with also in the case of external auditors. Much depends on whether the organisational function is centralised or decentralised.

11.10 Information System Audit and Control Association (ISACA)

If an occupational group desires to be identified as a profession, it should satisfy five basic conditions as under:

1. Existence of a common body of knowledge,
2. Existence of competency standards,

3. Conduct of a valid examination for assessment of competency,
4. Existence of a code of ethics, and
5. Enforcement mechanism of the code of ethics and disciplinary measures.

In 1969, EDP Auditors Association (EDPAA) was founded in Los Angeles as a professional body. In 1994 EDPAA changed its name to the Information System Audit and Control Association (ISACA). The Association has more than 14,000 members spread over in more than 100 countries with local chapters in more than 50 countries. It has a multi-volume publication called 'COBIT' (Control Objectives for Information and Related Technology) where the focus is on business processes. There is a list of control objectives, controls to be used to achieve the objectives, and audit procedures to determine the effectiveness and efficiency of the control system. The local chapters conduct regular technical sessions for its members. ISACA has an active research and publication program. It also publishes a quarterly journal called IS Audit & Control Journal. It has developed model undergraduate and postgraduate curricula for information systems auditing.

11.11 Practical Examples

11.11.1 Guidelines to conduct audit of computerised accounting system

The guidelines to conduct audit of computerised accounting system will comprise the following steps:–

» Understanding basic features of the computer-based system
- input documentation
- accounting system
- management information system
- control system

» Review of application documentation
- data contents
- procedures
- internal controls
- system flow charts
- input formats
- record layouts
- coding system
- exception

» Evaluation of controls
- preparation of control checklists
- appraisal of key activities

- » Designing test procedures
    - choosing testing techniques
    - testing processing operations
- » Using computers as audit tools
    - test deck
    - generalised audit program
- » Preparation of audit program
- » Compliance tests
- » Evaluation of audit results
- » Reporting to management.

11.11.2 A training program for the Internal Audit Department

A training program for the officers and staff of the Internal Audit Department may cover the following topics:

I. Introduction

- » Overview of the company.
- » Operations in various units and offices with future plan.
- » Current information technology.
- » Financial accounting and costing system followed.
- » Present audit coverage.

II. New Computerised System

- » Hardware, system software, file structure and processing techniques with special reference to distributed databases and client-server architecture.
- » Information system designed.
- » Codification.
- » Input-output documentation.
- » Data communication system.
- » Decision support system.

III. Control And Audit Aspect Of Computer-based System

- » Overview.
- » Changes in accounting and auditing environment brought about by computers.
- » Control system

- Input controls
- Processing controls
- Output controls
- Internal controls
- Audit trail
- Security controls

IV. Auditing In Computer Based Data Processing System

» Introduction.

» Understanding basic features of the computer-based system.

» Review of Application Documentation.

» Evaluation of controls.

» Designing test procedures.

» Application of selected audit procedures to critical controls.

» Analysis of audit results and reporting.

11.12.3 Steps in auditing computer application systems

The steps in auditing computer application systems are as under :–

I. Familiarisation with the application system

» Basic features of the system

» Codification system

» Data validation, error handling and control system

» Accounting implications

» Audit trail

II. Scrutiny of application documentation

» Input-output formats

» Data contents

» Procedures

» Internal controls

» User and operation manual

» System flow charts

III. Evaluation of system controls

- » Checklists
- » Preventive controls
- » Detective controls
- » Corrective controls
- » Security controls including application backup and recovery procedures

IV. Designing test procedures

- » selecting the testing techniques
- » auditing around the computer
- » auditing through the computer
- » using computer as audit tools (test decks/generalised audit program)
- » preparation of audit program

V. Compliance test of 'key' internal controls by application of selected audit procedures

VI. Analysis of audit results and reporting

- » evaluation of the application under audit
- » identification of weakness in the internal control system and impact thereof
- » recommendation for improvement
- » actions needed for implementation.

11.11.4 Example of outsourcing of internal audit jobs

Case Study

The Internal Audit Department of a public sector undertaking with diversified lines of production is centrally located in the Corporate Office in Kolkata. The company has seven manufacturing units in and around Kolkata and one unit in Bihar. It has liaison offices in New Delhi and Mumbai. It also maintains Guest House in New Delhi and Mumbai. The company maintains a database in the corporate office and online transaction processing accessed by terminals at various locations under a communication network. There are 3 officers and 12 staff in the Internal Audit Dept. 1 officer and 2 staff will be retiring within one year's time. As a policy, there will be no replenishment. It has been decided that existing 6 stock verifiers will be maintained for perpetual audit. Pre-audit of terminal benefits, pay related matters, strategic areas, system review, special reports for the management and audit committee, audit of unit in Bihar and liaison offices, replies to government audit will be continued with Internal Audit Dept. It is assessed by the management that the strength after retirement should be sufficient for this audit load. The remaining jobs may be outsourced in phases for which monitoring and control is to be exercised by the Internal Audit Dept. The jobs are required to be broadly categorised as per the above plan and submitted to the management for further direction.

Probable Solution

Separation of jobs into two categories

Category – I : Jobs to be done departmentallty

Pre-audit	Pay fixation	New appointments, promotion, pay revision, step-up, arrears payment, increment.
	Terminal benefits	Gratuity, Leave encashment, voluntary retirement scheme, enfacement of service folders
Cash	Verification	Cash at Main, and all Units Imprest cash including accounting thereof
Perpetual / Yearly	Perpetual stock taking	All activities/Projects/Sites/Units – including GRN/ SIR valuation, redundancy, Stock-out
(Material)	Year-end verification	Physical verification/valuation on test check basis
Post audit	Employee-related	Medical reimbursement, Interest subsidy on house building loan LTA, TA/DA Advances to employees Foreign Tour
	Departments	Guest Houses in New Delhi and Mumbai Unit in Bihar, Liaison Offices in New Delhi and Mumbai
Other	Routine	Tender opening
Jobs		Monitoring and reporting on Category II jobs
	Special (CAG, Audit Committee,	CAG audit replies Regular report and special requirement for Audit
	Management requirement)	Committee Special requirement of management
	Administrative	Purchase and Stores Analysis Control of rejected/surplus/non-moving materials Scrap sale – disposal procedures. Compliance of delegation of power

Category – II : Jobs which may be outsourced

Purchase	Capital	Purchase proposal, Asset Register, addition/deletion/ sale
	Other than capital purchase	Purchase proposal test-checking/timeliness of procurement action/vendor rating Demurrage
Material With Job Workers	Material Issues to job workers for execution of jobs	Bank guarantee/indemnity bond/return of scrap & surplus materials/rejections/ reconciliation/delivery control/insurance/excise formalities if applicable.
Services / Infra–Structural	Departments	Medical Dept. Transport Dept. Workmen's Canteen, Electricity Consumption
Shop Resources	Machines (including welding machines)	Machine utilisation/idle time
	Labour	Labour utilisation/idle time
	Material Handling Equipments	Utilisation/breakdown/idle time
	Tools & Consumables	Procurement/utilisation /consumption/scrapping
Payment	Creditors and Contractors	Advance/proforma/rejections/bank guarantees/ Letter of credit/Liquidated Damages/delivery control
Collection	Debtors	Billing/Advance/deductions/Liquidated Damages/ rejections/short-supplies/bank guarantee/Indemnity Bond/Letter of credit/outstanding
PAYROLL	Control aspect	Earnings/deductions/reconciliation/control
Insurance		Coverage/premiums/renewal/claims/realisation
COMPUTER	Information System	Efficiency of internal control system
	Audit	Control of input/output documents/time schedules. Audit trails Security controls & contingency plans Handling of users' requirement/complaints Audit through test packs.
SYSTEM	Review of systems & procedures	Purchase/Import/Stores/Cost-booking

11.12 Short Notes

11.12.1 Auditing around the computer and auditing through the computer

Auditing around the computer requires the following steps:

a) Selection of one or more critical output from the computer system.

b) Verification of the results exhibited by the output to ascertain correctness and completeness of the transactions processed.

c) Audit trail to locate the original source of input for verification.

Auditing through the computer implies verification of the computerised system itself and its efficacy to produce the correct and required output.

11.12.2 Principal methods of using computers as audit tools

Two principal methods of using computers as audit tools are:

Test Deck which is made up of dummy transaction data containing both valid and invalid conditions. These are used to test the effectiveness of programmed controls. The test deck can either be created by the auditor himself on the basis of review carried out or procured from reputed vendors marketing standard software package for the purpose. The processed result can then be compared with the predetermined result to ensure that the programmes are working accurately.

Generalised Audit Programmes which may be procured from the computer vendors/software companies for using computers in carrying out certain audit tasks e.g.

- Search and retrieve
- Test data generation
- Performing arithmetic operations
- Sorting, merging, matching, and comparing
- Copying
- Summarising
- Parallel simulation

11.12.3 Categories of controls

Preventive controls are designed to guard against risks inherent in certain data processing operations.

Detective controls are intended to arrest the consequences of what may bypass preventive control.

Corrective controls are detective types of controls that can be considered as complete only when key supplement corrective controls like formation of audit trails, installation of adequate backup and recovery procedures, implementation of automated error detection and correction techniques and other similar types.

11.12.4 Audit Trail

Audit trail refers to a system of designing of an information system in a manner that the historic data and information at any processing stage may be traced to verify the origin, correctness, authenticity, flow and destination including the stages of security procedures for establishment of integrity of data and information.

Problems for Self Examination

Q. 1. What are the characteristics of an Information System ?

Q. 2. Describe how growth of information system is contributing to business development ?

Q. 3. Describe how information system help in strategic planning.

Q. 4. Describe the requirement for a good Information System Infrastructure.

Q. 5. Draw a picture of good System Organisation and describe the role of different functional specialists.

Q. 6. Write short notes on

(i) High Level Language

(ii) Assembly Language

(iii) Debugging

(iv) Application software

(v) Virus

(vi) Fourth Generation Language

Q. 7. Describe the steps involved in System Development Life Cycle.

Q. 8. What is Systems flow chart ? How does it help in system designing ?

Q. 9. Describe the steps involved in Program Development.

Q. 10. What are major consideration for implementation of a system ? Describe the steps involved in System Implementation.

Q. 11. What are the requirements for a smooth System Change Over.

Q. 12. What are the components of systems development cost ?

Q. 13. Describe different types of file organisations and give comparison of these different types.

Q. 14. What is meant by Database Management System (DBMS) ? What are the advantages of DBMS over the conventional file management system ?

Q. 15. Draw a DBMS System Structure .

Q. 16. Describe different models of DBMS Structure.

Q. 17. What are the Code's Rules for stable Relational DBMS ?

Q. 18. Describe different activities involved in Data processing. What are factors you will be considering for deciding on mode of data processing.

Q. 19. Differentiate between batch processing and distributed data processing.

Q. 20. Write short notes :

(i) Protocol

(ii) Network Software

(iii) Centralised architecture

(iv) Client/Server architecture

(v) Local Area Network (LAN)

(vi) Wide Area Network (WAN)

Q. 21. What is meant by Network Topology. Describe three different types of network topologies.

Q. 22. Differentiate between Internet and Intranet. What are common problems faced in Internet ?

Q. 23. Give the advantages of e-mail.

Q 24. How e-commerce can provide different types of prospect in business world ? According to you, what are the issues to be addressed for effective role of e-commerce.

Q. 25. What is Data warehousing ? What are the critical factors involved in data warehousing.

Q. 26. What is Data Mining ? Narrate the services provided by data mining.

Q. 27. What is meant by Knowledge Management ? How does it provide good solution in business ?

Q. 28. What is Business Process Re-engineering (BPR) ? Does it contribute in effective resource management.

Q. 29. Write short notes on :

(i) Expert System

(ii) Artificial Intelligence

(iii) Decision making process

(iv) Decision Support System

Q. 30. What are the objectives of developing a good Management Information System ?

Q. 31. What are the steps involved in developing an MIS ?

Q. 32. What are different approaches for developing MIS ?

Q. 33. What are the constraints commonly faced in operating an MIS?

Q. 34. Describe the limitations commonly encountered in operating an MIS ?

Q. 35. Why an ERP Package is getting popular these days ? How BPR helps in implementing an ERP System ?

Q. 36. What are the steps involved in implantation of an ERP System ?

Q. 37. What is the selection process for an ERP Package ? What are the cost components for implantation of ERP System ?

Q. 38. Name and describe some common modules of an ERP System ?

Q. 39. What are different risk factors in an Information system and how they are to be controlled ?

Q. 40. What methodology do you propose to minimise risk in operation of a system ?

Q. 41. What do you propose to create a proper processing environment ? What are the controls for a good processing environment ?

Q. 42. What are preventive measures do you propose against damage in processing ?

Q. 43. What is Computer fraud ?

Q. 44. What is the implication of auditing around the and auditing through the computer ?

Q. 45. Describe the various steps in auditing computer application systems.

Q. 46. Describe two principal methods of using computers as audit tools. On what basis do you categorise controls as preventive, detective and corrective?

Q. 47. Draft guidelines to conduct audit under the computerised environment.

Q. 48. Draw a training programme for the officers and staff of the Internal Audit Dept.

Q. 49. Discuss about the utility of documentation in supporting an information system. Is a program library essential?

Q. 50. What are the criteria for recognition of a profession ? What is ISACA ?

Q. 51. Write short notes on:

(i) Audit Charter

(ii) Audit Trail

(iii) Outsourcing of Internal Audit Jobs

(iv) Evaluation of System Controls

Revisional Questions

Revisional Questions

Question 1:

Write short notes on : 4×5=20

i) Open system

ii) Internet

iii) Electronic Mail

iv) LAN, Ring Network, Star Network

v) Scanner

Question 2 :

(a) Briefly explain Decision Support Systems (DSS) illustrating how they are used and by whom. 10

(b) What is an operating system ? What are its basic functions ? 10

Question 3 :

(a) What tools and techniques are used during system design ? 10

(b) What should be included in the written design specifications ? 10

Question 4 :

(a) What is an electronic mail ? 3

(b) What is modem ? Why is it required in data communication ? 8

(c) According to you what factors affect the security of the computer system of an organisation ? 5

(d) What is meant by "backup" of computer files ? Why is it necessary to keep back up of computer file ? 4

Question 5 :

Explain the following :

I. System concept 4×5=20

II. Source document

III. System & subsystem

IV. Debugging the programme

V. Data flow diagram

Question 6 :

(a) Explain the concept of Data Base Management System. What are its benefits? 10

(b) Describe five input control techniques. 5

(c) What is the need for providing system control ? 5

Question 7 :

(a) What is system changeover ? What are the different methods of changeover? 10

(b) Explain the main stages of system project life cycle. 10

Question 8 :

(a) Distinguish between decision support system & executive information system. 10

(b) Explain briefly the main functions of an operating system. 5

(c) What is the difference between operating system software and application software. 5

Question 9 :

(a) What are the different types of file ? Explain the Transaction file. 10

(b) What is BUS and what are the different types of BUS. 10

Question 10 :

(a) What is Internet ? 10

(b) Write short notes on :

(i) DHTML

(ii) JAVA

(iii) e-mail

(iv) Extranet

(v) World Wide Web 2×5

Question 11 :

(a) What are the main objectives of MIS ? 10

(b) Explain the difference between LAN and WAN. 10

Question 12 :

Select True/False from the following statements : (1×15 = 15)

(i) All managers in a big organisation use the same type of information.

(ii) Sequential files are suited for on-line inquiry processing.

(iii) E-mail reaches its destination instantly.

(iv) A computer is an electronic data processing machine used by several persons at a time.

(v) In LAN each computer can fulfil a function.

(vi) There is no difference between a LAN and a computer network.

(vii) CD-ROM are produced on a mass scale.

(viii) All hardwares features are available to an assembly language programmer.

(ix) Memory is used to store data, programs and results.

(x) CPU can read information directly from secondary memory.

(xi) Only executable files can be infected by virus.

(xii) Processing is done in the primary storage unit.

(xiii) Light pens and Joysticks are both pointing devices.

(xiv) To start an accessory, after positioning the pointer, double click the left mouse button.

(xv) On-line processing and real-time processing are same.

Question 13 :

Match words and phrases in left column with the nearest meaning in the right column.

(i) Arrangement of records in file	(a) E-mail	1×10
(ii) Processing has fixed time constraints	(b) File organisation	
(iii) Transmission of letter, message, memos over communication net works.	(c) Operating system	
(iv) Processing information of physical nature	(d) Protocol	
(v) Transferring programs from main memory to disk storage and back	(e) Baud rate	
(vi) Device dependent software	(f) Icon	
(vii) A program/utility under Windows	(g) Swapping	
(viii) Transmission speed of communication channel	(h) Link	
(ix) Any device to offer service to LAN users	(i) Real-time processing	
(x) Set of rules for orderly transfer of data among	(j) Servernetwork users.	

Question 14 :

(a) The HR department of a company is considering the implementation of a Human Resources Information System. They have two options-either to buy a ready-made package or to get it developed by a software services company. What are the pros and cons of each of these options? 10

(b) What do you understand by the term "system" ? What are its characteristics ? What do you understand by integration of systems? 10

Question 15 :

(a) What is an interface device ? Describe three such devices that are commonly available. 6

(b) State the full form of —

(a) DSS

(b) MODEM

(c) SDLC

(d) EDI 4

(c) Describe briefly the basic components of a computer. If you wish to use your computer for internet surfing and e-mailing, what would be the additional requirements in respect of hardware and software? Draw a diagram showing the connectivity with the internet. 5+3+2=10

Question 16 :

(a) You as a Finance Manager, has received a proposal from your IT Department to enter into an Annual Maintenance Contract (AMC) for an ERP software that has been implemented in the company. Considering the fact that ERP packages are proven software packages, why should the company enter into a maintenance contract? 8

(b) Write short notes on :

(i) Multiprocessing,

(ii) Distributed Data Processing 4+4=8

(c) State "True" or "False": 1×4=4

(i) A scanner is both an input and output device.

(ii) “Power Point” is not a spreadsheet software.

(iii) A computer virus and a program bug are not synonymous.

(iv) Data security and Data privacy mean the same thing.

Question 17 :

(a) “A business graph is a visual representation of numerical business data in an analytical manner so as to facilitate quick grasping of the inherent features.”

Name any five types of business graphs commonly used. 5

(b) In the context of internet, please define:

(i) E-commerce

(ii) E-money

(iii) E-mail

(iv) Webmaster

(v) Yahoo !

(vi) Information highway.

Question 18 :

(a) "The success of a computer based information system greatly depends on a good coding system". What is a code ? What are the characteristics of a good coding system ? Describe at least three methods of structuring codes with examples. 12

(b) Distinguish between : 4+4=8

(i) Master file and Transaction file;

(ii) Sorting and Merging of files.

Question 19 :

(a) How do you judge one CPU as more powerful than the other ? Name five major attributes which add up to making such decision. 5

(b) Match the following two columns :

(i)	Search Engine	(a)	A method used to make hypertext documents readable on the World Wide Web.
(ii)	HTML	(b)	A place where users can experiment with Internet services available, take expert assistance, undertake training courses, etc.
(iii)	Web Browser	(c)	A list of common questions and sometimes with answers.
(iv)	FAQ	(d)	A Web site enabling users to access various levels of information.
(v)	HTTP	(e)	Web sites that allow users to communicate with various other users on-line.
(vi)	JAVA	(f)	A program that enables a computer to download and view pages of the Web.
(vii)	Chat Rooms format	(g)	An encoding scheme used to create a Web document.
(viii)	Cybercafes	(h)	A language system that delivers programs to users which can then be run on the users' machines.
(ix)	Microsoft Excel	(i)	A programming language.
(x)	C++	(j)	Spreadsheet package.

(c) Define a URL in the context of Internet. What role does it play ? 5

(d) What do you mean by 'protocol' ? What does it include ? 5

Question 20 :

(a) "Digital signatures do for electronic documents what handwritten documents do for printed documents." What is a digital signature ? How is it created and verified ? 10

(b) State 'True' and 'False' and the basis for your decision : 2×5=10

(i) A System Designer ends his job where a System Analyst begins.

(ii) The higher the management, more structured are the problems.

(iii) 'Data' and 'Information' are synonymous.

(iv) In Binary Numbering System 'bits' and 'bytes' convey different meaning.

(v) Primary Storage and Secondary Storage are two sections of the CPU.

Question 21 :

(a) You have been engaged as Management Consultant for the computerisation plan undertaken by a large manufacturing company. Before assessing the information needs, you have requested to identify at least three major activities under each of the following functions of the company : 10

(i) Manufacturing;

(ii) Marketing; and

(iii) Finance and Accounting.

(b) Name three principal methods of creating databases. Describe any one method in detail. 10

Question 22 :

(a) What is a knowledge-based system? How does it differ from an Expert System? 10

(b) Explain the concept of database Management System. What is a Relational Database System? 10

Question 23 :

A parcel carrying transport company has nine branches situated in South India. The top management want to have the figures on the various functions on a day to day basis, so that daily performance can be evaluated the next day.

(a) List out the data required for this purpose and give the formats for sending the data daily by next day morning. 5

(b) How should these data be collected by the head office to evaluate the daily performance ? 5

(c) State the used of computers at branches and at head office. 5

(d) What precautionary measures should be taken to prevent the error ? 5

Question 24 :

(a) A company having multiple offices all over India, has decided to install an ERP package for its financial accounting in all its offices. Two options were considered :

(i) a centralized architecture in which the database will be stored centrally in Head Office and all offices will access it via VSAT connectivity, and

(ii) a decentralized architecture in which each office will maintain its own database,

which would periodically be merged at Head Office for consolidation.
What are the advantages and disadvantages of the two architectures? 5

(b) "While computerization has an array of advantages, it also exposes the company to a number of hazards." Name some of these hazards, and some measures to avoid them. 5

(c) Describe systematically the steps involved in program development. What do you understand by "top-down approach" to program design? 5+5

Question 25 :

(a) You have been given the responsibility of implementing a new software package in place of a running old one. What techniques would you consider in changing over from the old to the new system ? 6

(b) What is Data processing? Describe the basic components of a computerized Data processing system. 2+6

(c) What types of control are usually exercised on computer outputs ? 6

Question 26 :

Indulekha Fabricators Ltd. executes orders of general engineering nature. They have four units in and around Kolkata. They have recently introduced computer-based information and accounting system, covering all the units including Corporate Office. They have also decided to introduce E-mail facility and maintain Web site of their own. As a result, changes have taken place in the accounting and auditing environment, especially with regard to the control system. The company has assigned you the task of preparing training materials for training the officers and staff of their Internal Audit Deptt. in order to be able to take up this new challenge. 8+8+4

Please prepare :

(i) the broad heading and subheading of topics to be covered in the training materials;

(ii) guidelines to conduct audit of computerised accounting system;

(iii) implication of auditing around the computer and auditing through the computer.

Question 27 :

(a) A company engaged in steel manufacturing activities is considering the implementation of an ERP system. The company has a few computerised applications running in different areas of the organisation. All these will be discontinueded after ERP system is implemented. 15

A software firm has given a quotation for the new system which states that the implementation will take a little more than a year and the capital cost will be Rs. 86 lakhs (payable as Rs. 55 lakhs in the first year and Rs. 31 lakhs in the second year). The management is wondering as to when the ERP system will recover all of its initial costs and start making a profit. What would be your answer based on the above data ?

The following information about Operational Costs (Rs. lakhs) are also available :

	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*
Old system	25	28	34	45	47
New system	—	7	14	15	16

(b) What do you understand by quality in regard to software ? Then what are tools used for quality assurance of software ?

(c) Write note on System Changeover Methods.

Question 28 :

(a) What is World Wide Web ? How would you distinguish it from Internet ? 2+3=5

(b) In a Purchase Order Processing system, a purchase order record has the following fields :

Field Name	Maximum Field Size
Purchase-order-number	6
Vendor Code	3
Order-quantity	5
Order-date	6

It is estimated that at any point of time, the outstanding Purchase Order file would have a maximum of 750 outstanding purchase order records in the file (once material is received, the purchase order record is purged from the file). However, there may be a 15% increase in the total number of records in near future. The file management software also requires an overhead of 20% for minimising probabilities of collision and overflow conditions. Compute the total file space requirements after allowing for 10% contingency factor on the total.7

(c) Distinguish between File Retention and File Recovery. 4

Question 29 :

(a) Distinguish between Data Integrity, Security and Privacy in regard to computer databases. 5

(b) Distinguisg between structured and unstructured decision. 5

(c) In a company, it is a regular procedure that the Sales Order master file on hard disk is backed up on a Cartridge Tape at the end of each day. The system provides that all the transactions that update the master file are available on a Transaction log file, which is also backed up on a tape at the end of each day. During a particular day, both the master file and the Transaction log file on the hard disk got destroyed. Draw a diagram showing how the master file could be reconstructed on the disk with the help of backed up files. 10

Question 30 :

(a) Your computer is considering three options to acquire software for computerising one of its functional area. The options are :–

(i) Buying a readymade software package,

(ii) Engaging an outside software firm to develop the software, and

(iii) Developing the software in-house by own IT department. What are the pros and cons of each option ? 10

(b) What is prototyping approach of developing systems ? What are the advantages and disadvantages of the same ? What are the two types of prototyping approaches to system development ? 10

Suggested Answer to Revisional Questions

Answer to Question 1 :

i) ***Open System :*** An open system is one which interacts with its environment and can change itself to accommodate the changes in factors like customers' preference, price, product design etc. The adoptability of an open system is judged by its capability in modifying the operational parameters of the system accordingly. It takes input from outside world and exports output to outside world. For example, a Financial Management system can function smoothly even with the change in credit period and credit limit from the banker is said to be having the flexibility to adjust itself with the change the environmental parameters. If a system can accommodate all the changes in the environmental factors, as and when required, is said to be perfectly open system.

ii) ***Internet*** is worldwide network of databases and users. Any member of the lnternet can access any of the databases through his personal computer. Each user is given an ID number. The user can download texts, graphs and data from other databases. Similarly the user can create database which can be accessed by others. Internet facilitates international trade and commerce. lnternet helps in sharing of knowledge and enables effective, cheap and fast communication across the world. It requires a modem, a personal computer, a telephone and the services of a service provider.

iii) ***Electronic Mail :*** This refers to transfer of information from one computer to another. The full expansion is electronic mail. It means that two computers, whatever may the distance between them, can be connected together through communication technology. E-Mail enables one user to transfer information, receive information and hold a dialogue with the other. The advantage is low cost high speed communication.

iv) ***Local Area Network (LAN)*** is a network of computers within a limited geographical area, often within the same building but sometimes within a few kilometers as opposed to Wide Area Network (WAN) which can cover wide geographical area across cities and countries.

There are two configurations of computers in a network :

Ring Network - In a ring network the computers arranged in a circular fashion. There is no central or host computer. The disadvantages of ring network is that the failure in any one computer in the network causes the entire network to fail.

Star Network - In a star network, there is a host or central computer which is attached to the computers in the network through multiple communication lines. All the computers communicate with each other through the host computer. Unlike in the ring network, the entire network does not fail if any of the computer in the network fail.

Answer to Question 2 :

a) *Decision Support Systems (DSS) :*

DSS is a combination of hardware and software to aid decision making. It includes Data Base (DBMS), Model Base (MBMS), Knowledge Base (KBMS) and Dialogue Systems (DGMS). DSS is designed to aid the decision making functions of the Management. Management, at the lower levels, has to deal with structured problems. Higher and Middle level managements, have to deal with strategic aspects of decision making where the problems are unstructured. These levels of managements, need tools that can enhance their capabilities in the area of predicting the outcome of future course of actions. An important component of DSS is stimulation, i.e. construction of mathematical/statistical models for evaluating the behaviour of real variables.

Data Base Management Systems (DBMS) : This refers to a Data Base Management System software like Ingress or Oracle, that helps in organising the data and facilitates easy accessibility through query language for the decision makers, to retrieve any type of data depending on the decision environment.

Model Base Management System (MBMS) : This refers to a Model Base Management Systems that facilitates representation of a decision environment and stimulate the results of various alternative plans of action. This helps in improving the quality of decision making.

Model base management systems include special purpose models like linear programming models etc. that help in decision making situations like production planning and optimisation.

Knowledge Base Management System (KBMS) : KBMS refers to Knowledge Base Management Systems. This is a recent development in applications of artificial intelligence. These systems capture the experience of a decision maker in the form of rules so that rule base can be used by another decision maker for decision making. These are known as Expert systems for Decision making.

b) Operating System :

An operating system is an integrated act of specialised programme that are used to manage the overall resources of and operations of the computer. It is specialised software that controls/monitors the execution of all other programs that reside in the computer, including application program and other system software. Major functions of an operating system are —

i. Job Management

ii. Scheduling

iii. Acceptance of tasks

iv. Communication with terminals

v. Computer resources management

vi. Data management

vii. Job accounting

viii. Access control.

Answer to Question 3 :

(a) The following tools and techniques are among those used during system design —

(i) ***Organisation standards*** **–** Some organisations have standards/manuals that specify a consistent design approach. The procedures to follow in designing output reports, input forms, and processing logic may also be spelled out.

(ii) ***Top-down design methodology*** **–** The top-down design techniques requires the early identification of the top-level functions in the proposed system. Each function is then broken down into a hierarchy of understandable lower level modules and components. A top-level chart shows how the total structure of the system is prepared, lower-level diagrams are created to show the input/

processing/output details of each function, module, and component. Several iterations will usually occur in this design and charting process. Designers may start with simple diagrams showing general solutions. This first effort is then refined to produce more complete charts as the design requirements become clearer.

(iii) ***Design reviews and walkthrough –*** Periodic sessions may be held so that interested users can review the design process. Users can be encouraged to look for errors and to make comments during this design walkthrough.

(iv) ***Special charts and forms –*** The charts and forms prepared during the system analysis phase are very helpful in the design stage. Weaknesses spotted during analysis can now be corrected. And the existing input/processing/output relationships may now be used to design a more integrated system.

(v) ***Automated design approaches –*** Special computer programs can be used to evaluate various hardware/software alternatives during the design stage. Processing requirements can be supplied, and a computer program can then determine how efficiently these requirements can be processed using different equipment alternatives.

(b) Usually the designers have prepared a detailed set of written and documented system specifications to achieve the system study goals. These specifications should include :–

(i) ***Output requirements*** – The form, content, and frequency of output is needed.

(ii) ***Input requirements*** – The necessary new input data should be identified along with the stored file data that are required.

(iii) ***File and storage requirements*** – The size, contents, storage media, record formats, access restrictions, and degree of permanency of any affected files should be known.

(iv) ***Processing specifications*** – The procedures needed for the computer to convert input data into desired output results should be indicated. Manual processing procedures should also be noted.

(v) ***Control provisions*** – The steps required to achieve system control should be specified, and the later system testing and implementation procedures should be outlined.

(vi) ***Cost estimates*** – preliminary estimates of the costs of different alternatives should be made.

Answer to Question 4 :

(a) E-mail is the single most important reason to use the internet. It is quite similar to the postal mailing system. The service is provided by E-mail service provider, who maintains a computer with a large storage place. The customers are provided an address, which is used for communication. A customer desiring to communicate with another, sends the mail to the address of the receiver using a special software. If the computer of the receiver is not in use, the message gets stored in the service provider's computer. When the receiver switches on his computer, he is immediately informed that he has a ''mail'', he can read the mail and answer it. The advantage of E-mail is that the message get delivered even when the receiver is not available. But the system, in addition to a telephone needs a computer with proper software and a modem.

(b) A Modem is an electronic device which is used converting digital signals to analog waves and vice versa. The process of converting a digital signal to analog signal is called modulation and reverse process is called demodulation. Modem is a short form for Modulator - Demodulator. Modem is essential for data communication. If the telephone system is to be used for connecting up with distant computers, as the signal generated in a computer is digital and those handled by the telephone system, so for is analog.

(c) Factors affect the security of the computer system - Normally there are three types of factors which may affect the security of computer system of an organisation —

Physical factor

(i) Non–protection of computer hardware from fire, flood, theft, dust, humidity, earthquakes, power fluctuations etc.

(ii) Non–protection of computer software from fire, flood, theft, dust, humidity, earth quakes, power fluctuations etc.

(iii) Non–protection of building housing with the computer facility from fire, flood, earthquakes, etc.

System factor

(i) Loss of data, software, damage to equipments.

(ii) Malfunctioning of the system due to hardware failure and error in software.

(iii) Non-availability of backup of data/Software.

Human factor

Risk due to unintentional/intentional activities of others. Unintentional activities may be due to accidental effects of wrong changes to data, wrong deletion of files/programs, running of a wrong program, forgetting the password etc. Intentional activities are unauthorised deletion/corruption of data/files etc.

(d) The storage devices used, especially the disks, in a computer system are not very reliable being susceptible to becoming bad, which may be caused by "bad sectors", the storage location becoming partially bad. Also, the possibility of total disk failure, called ‘‘erasing’’ can not be ruled out. All these would cause loss of the data/program stored. To avoid such a loss, a duplicate copy of the data and program files are kept in a separate storage devise, which is called back ups. For example, the files from hard disks are backed up in floppies, tapes, or tape cartridges. A separate utility is used for crating back ups, where the files which are being copied, are combined to make better utilisation of the storage space.

Answer to Question 5 :

I. ***System concept :*** The term "system" is used often and in different ways. A system is a group of integrated parts that have the common purpose of achieving some objective(s). The key characteristics of a system are —

- A group of parts - a system has more than one element
- Integrated parts - A logical relationship must exist between the parts of a system.
- Common purpose of achieving some objective(s). The system is designed to accomplish one or more objectives. All system elements should be controlled so that the system goal is achieved.

II. ***Source document :*** Data must be originated in some form and verified for accuracy prior to further processing. They may initially be recorded on proper source documents and then converted into a machine - usable form for processing or they may be captured directly in a paperless machine-readable form.

III. ***System and subsystem :*** A Computer is a group of integrated parts that have the common purpose of performing the operations called for in the program being executed. It also is a system. Any system may be comprised of smaller systems or sub-systems. A subsystem is a smaller system contained within a larger one.

IV. ***Debugging the program :*** The first step in program implementation is to debug the program i.e. to detect and correct errors that prevent the program from running. Testing the results produced by the program to see if they are correct is the next implementation step. And ensuring that a complete documentation package is available for the application is a third implementation step.

V. ***DFD*** is a simple method of refreshening input, process and outputs, within an information system and can be suitably adapted for use at the data gathering stage of system analysis, to depict procedures as they are being currently carried out, as well as, for showing the flow of data through the program at design stage along with transformations in data, resulting from processing.

Answer to Question 6 :

a) **Concept of DBMS -** Data Base Management System (DBMS) is a tool for managing information as a 'resource which overcomes the limitations of traditional file design. Its main focus is one ease of file creation, reorganisation summary, report generation and updation. In short it aims at easing the transaction processing routine and information access. It seeks to avoid duplicate data creation. Information is the resource of a Company. Hence it is essential that the discipline and importance traditionally apply to the management to the other resources like man, machine, materials and money are applied to information too. Database management systems manage the data of a company in such a way that the data are structured and related, and hence obtainable in a more orderly and logical fashion.

In traditional file design, files are designed for a specific reporting requirement with little regard to files designed for other reports. For example, one analyst designed a customer master file for an accounts receivable system without any regard to the customer file designed in a related system like sales order processing which also maintain data about customers. As a result, there were inconsistencies and redundancies of data among various information systems. In the DBMS environment there are two individual files for a particular system. Rather, a centralised data base is created and controlled which becomes common to all information systems.

Generally DBMS performs the following functions :

- Organises data in a manner most suitable to each application
- Integrates data by establishing relationship between data elements.
- Separates data by distinguishing between logical description and relationship of data from the way the data is physically stored.
- Controls how and when data is physically stored

- Locates and provides data to the programs
- Protects data from unauthorised accesses, operating system failures, inconsistencies in updates etc.

Benefits of DBMS :

- Reduced programming costs because many input-output routine normally coded by programmers are handled by DBMS itself.
- Reduced system maintenance cost because of many common causes of system failures like input / output, file description, etc. are handled via DBMS.
- Reduced data redundancy because each element of data is maintained by a single source.
- Increased reliability of data because of checks and control mechanisms inherent in DBMS.
- Consistency of data because of each element of data is maintained in one place only.
- Easy retrieval of data through query language.

b) Input Control Techniques :

1. **Editing :** Checking for completeness, validity and consistency of data.
2. **Item counts and control totals :** In a batch processing system, the number of items being input and total of certain fields. For example, number of invoices being entered and the grand total of all invoices.
3. **Sequential number of documents :** Numbering all input documents sequentially and checking with the total of documents entered.
4. **User codes and password :** Only those people having a user code and password will have access to the system and be able to input data.
5. **Recording of receipts of documents :** Recording of logging in the data, volume and other information about data received from outside the system.

c) Needs for providing system controls

- internal control is a significant management obligation. System control is a part of the internal control mechanism.
- With increasing computerisation, the traditional security, audit and control mechanisms take on a new and different form.
- The increasing complexity of complex on-line data communication oriented system make companies vulnerable to unauthorised manipulations of data, program and operating procedures.
- Many of the computerised systems now cut across many departments, lines of responsibility and even geographical boundaries. Hence the traditional control mechanisms become ineffective in many cases.

Answer to Question 7 :

a) **System Changeover :**

The changeover is the process of changing over from the old system to new system. It is the last stage of system development process. When the new system has been developed, it has to replace the old system. The process begins when the programming and testing of the new system has been completed and by training the users with the new system, by creating the new data base and by installing the necessary equipment. It is a critical phase in that the method and style of changeover will determine the users response and attitude towards the system.

Different Methods of changeover :

Three alternatives are available for changeover from the old system to the new system -

- ***Crash Method -*** The old system is discontinued and the new system is implemented simultaneously.
- ***Parallel method -*** The old and the new system is run concurrently for a period until the new system works to the satisfaction of all concerned.
- ***Staged method -*** The old system is replaced gradually by stages.

b) The total process of developing a system under the modern approach is divided into four stages called —

(1) System Analysis

(2) System Design

(3) System Implementation

(4) System Support

In the first phase, it can be termed as the starting phase, an analysis is made of the existing system of working to draw an outline of the new system which would meet the requirement of the user. The second stage can be termed as the development phase, when the detailed design of the proposed system is drawn up. It also involves acquiring the hardware with necessary supporting software. The third phase called implementation stage, involves implementing the new system designed, i.e. making it operational. The last stage called system support phase is involved in giving finishing touch to the system developed. However, it should be noted that these four stages are not isolated compartments and these are also not followed serially - often one has to go back to the previous stage to incorporate modifications and new ideas, till the total job of successfully commissioning the system is completed.

Answer to Question 8 :

(a) Decision Support System (DSS) are programs tailored to the management needs and designed to aid decision making functions. The lower level management normally deals the structured problem which involves processing of transactions, keeping records and providing reports or routine activities. Higher and middle level management deal with strategic and technical aspects of business decision. They therefore need aids which enhance their capabilities in the area of predicting the outcome of future course of actions. An important component of DSS is stimulation i.e. construction of mathematical/ statistical models for evaluating the behaviour of real variables. DSS includes DBMS, KBMS and dialogue system (DGMS).

An Executive information system (EIS) is a refinement of the DSS which enables an executive to navigate through the data base and view the database from multidimensional angles.

An EIS is a software that can facilitate navigation in any dimension within the database created out of transaction processing systems.

(b) The main functions of any operating system (OS) are as follows –

1. Processor Management : The OS assigns different tasks to the processor and monitors their execution.

2. Memory Management : The OS allocates main memories and other storage areas to the system programs and other programs and data.

3. Input / Output management : It coordinates and controls the working of the various input/ output devices like the Disk Drives, the Monitor, the Printer etc.

4. File Management : It handles the storage of information in the form of files on various storage devices and transfer of these files from one device to another.

5. Interpretation of commands : The OS interprets the commands and instructions issued by the user or an application program and executes them.

6. Job priority : It determines and maintains the order in which jobs are to be executed in the computer system.

(c) Operating system software : The operating system software is a set of program instruction that act as a interface or layer between the user and the application program and the computer hard ware. It supervises and directs the operations of the computer. Essentially, it performs three tasks : it manages devices like storage and retrieval of files from the hard disk, it controls program execution and processes commands that are entered by the user. Some popular operating software are MS-DOS, UNIX, NETWARE, WINDOWS-95 etc.

Application software : An application program is one which is designed to be used for a specific purpose that is useful to man. Word processing, Accounting are some specific application areas for which such software is written. All Transaction processing is done through Application programs which can vary from simple accounting packages to complex Enterprises Resource Planning Packages which uses a Database package as backend.

(d) ***ROMs and RAMs :*** Semiconductor memories are of two types : RAM (Random Access Memory) and ROM (Read Only Memory). RAM is a read / write memory. Information can be written into and read from a RAM. It is a volatile memory. It stores information so long as power supply is on. When power supply goes off or interrupted the stored information in the RAM is lost. ROM is a permanent type memory. Its contents are decided by the manufacturer and written at the time of manufacture. RAMs of various capacities are available, for example, 1M, 4M, and 16M etc.

Answer to Question 9 :

(a) There are five broad categories of Data file used in any information system.

Master

Transaction

Work

Backup

Security

Audit

Transaction Files

Transaction Files are files in which the data relating to day to day business events are recorded, prior to a further stage of processing. This further processing may be the use of the transaction data to update master files, or the arriving of the transaction for audit purposes. After the transaction file is processed it usually re-initialised, and further transactions are recorded in it. Examples of transaction files are :

Customer's Orders for products (to update an order file)

Details of price changes for products (to update a product file)

Details of cash posting to customer accounts (to be held for audit purposes)

Once a master file has been created, it must be kept current. File changes come from a number of sources, including business activities, the activities of individuals or changes in governmental policy. The documents or data created by these activities are commonly called transactions.

Transaction data may be collected automatically or may initially be recorded on source document and later converted to a machine-readable format.

(b) The BUS

The various chips on the motherboard have to be connected in some way, so that they can pass signals back and forth and communicate with each other. This is done by setting up a common communication channel i.e. a set of wires that acts as a common carrier for signals passing from one component to another. This channel of wires is called a bus. These buses also provide an electrical interconnection between the processor components and the interface devices used with peripheral equipment (serial interface, parallel interface).

There are three different types of buses on the motherboard which connect all the components with each other. These are : The Data Bus, The Address Bus and The Control Bus. All instructions consist of two parts, the first part of the instruction indicates the operation to be performed and the later part contains the address of the data that are to be used by the instruction (not the data itself). The processor sends the addresses over the address lines of the bus to RAM. From the RAM, it gets back the contents of that address over the data lines of the bus. The processor then executes the instruction. The Control bus carries the control signals to and from the control sections of the processor thereby controlling the entire processing.

Answer to Question 10 :

(a) The **Internet** is a worldwide network of networks. It is a conglomeration of smaller networks and other connected machines spanning the entire globe. It consists of over thirty thousand networks in 71 countries. Around the world, each country has at least one backbone network that operates at a very high speed and carries the bulk of the traffic. Other smaller networks connect to that backbone.

The Internet has no central authority – networks on the Internet simply agree to cooperate with each other. Individual computers on this networks can share files and transmit information. Various networks connected to the Internet format messages with Internet Protocol (IP). IP is often used in conjunction with TCP (Transmission Control Protocol). The combination of TCP/IP have made the Internet robust and flexible.

(b) ***(i)*** ***DHTML (Dynamic Hyper Text Markup Language) :*** This is the latest version of HTML that is still being designed. DHTML solves a huge list of problems associated with laying out webpage designs.

(ii) ***JAVA :*** This is a new language. Destined to change the Internet in a way very wonderful. This language can allow you to do incredibly versatile things via web pages running programs.

(iii) ***e-mail : Electronic mail -*** It is an electronic means of sending message from one computer to another in an organised fashion. Sending e-mail uses the SMTP protocol

(iv) ***Extranet :*** An extension of a corporate internet. It connects the internal network of one company with the internets of its customers and suppliers. This make it possible to create e-commerce applications that link all aspects of a business relationship, from ordering to payment.

(v) ***World Wide Web :*** It is also known as just "the web" or WWW , this is perhaps the main reason for the internet's growing popularity in recent years. Based on a client server architecture, the web consists of numerous servers on the internet. A server is identified by an address in a special format, called the Uniform Resource Locator.

A web site is a computer server with databases and connectivity. It has homepages of its own or for its customers on rent. A homepage can be set up at customer's own site with appropriate information. The homepage can serve as a mirror of an organisation that provides financial data, on-line order forms etc.

Answer to Question 11 :

(a) A Management Information System (MIS) should provide –

(i) Current information for monitoring and control.

(ii) Accurate information about the system

(iii) Timely information out of large volume of data.

(iv) Economical information (low cost)

(v) Relevant information for decision making.

(b) ***Decision Support Systems (DSS)***, is a combination of hardware and software to aid decision making. It includes Database (DBMS), Model Base (MBMS), Knowledge base (KBMS) and Dialogue Systems (DGMS). DSS is designed to aid the decision making functions of the management. Management at the lower levels has to deal with structured problems. Higher and middle level managements have to deal with strategic aspects of decision making where the problems are unstructured. These levels of managements need tools that can enhance their capabilities in the area of predicting the outcome of future course actions. An important component of DSS is simulation, i.e. construction of mathematical/ statistical models for evaluating the behaviour of real variables.

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Model Base Management System includes special purpose models like linear programming models etc. that help in decision making situations like production planning and optimisation.

Knowledge Base Management System (KBMS) : KBMS refers to Knowledge Base Management System. This is a recent development in applications of artificial intelligence. These systems capture the experience of a decision maker in the form of rule so that such rule base can be used by another decision maker for decision making. These are known as expert systems for decision making.

(c) **Difference between LAN and WAN :**

1. A LAN is restricted to a limited geographical coverage of a few kilometres, but a WAN span greater distance and may operate nationwide or even worldwide.
2. The cost to transmit data in a LAN is negligible since the transmission medium is usually owned by user organisation. However in case of WAN, this cost may be very high because the transmission medium used are leased lines or public systems such as telephone lines, microwave and satellite links.
3 In a LAN the computer, terminals and peripheral devices are usually physically connected with wires and coaxial cables. Whereas in a WAN there may not be a direct physical connection between various computers.
4 Data transmission speed is much higher in LAN than in a WAN.
5. Fewer data transmission errors occur in case of a LAN as compared to a WAN. This is mainly because in case of a LAN, the distance covered by the data is negligible as compared to a WAN.

Answer to Question 12 :

(i) F

(ii) F

(iii) F

(iv) T

(v) T

(vi) F

(vii) T

(viii) T

(ix) T

(x) F

(xi) F

(xii) F

(xiii) T

(xiv) T

(xv) F

Answer to Question 13 :

(i) B

(ii) I

(iii) A

(iv) H

(v) G

(vi) C

(vii) F

(viii) E

(ix) J

(x) D

Answer to Question 14 :

(a)

Type of Software	*Advantages*	*Disadvantages*
Buying readymade	1. Can be seen and tested 2. Will have few bugs. 3. May be less costly. 4. Time saving in implementation. 5. Documentation/help facilities.	1. May not meet requirements fully. 2. Enhancements / modifications may be expensive & time consuming. 3. Procedures, methods, Forms, etc may have to be changed.

Type of Software	*Advantages*	*Disadvantages*
Built by an outside firm	1. Better control over schedule and cost	1. Difficult to negotiate on effort and time required.
	2. Does not affect day-to-day systems operations due to development work.	2. Difficult to implement without adequate technical knowledge of the software
	3. Ready skills when new hardware or software platforms.	3. Difficult to maintain after implementation.
		4. Unfamiliarity of the outside party with business may hamper quality.

(b) A **system** is an organised grouping of components-persons, methods, machines and materials that are collectively set to accomplish some specified objectives.

The characteristics of a system include Objectives, Components, Structures, Behaviour and Life Cycle.

When all information in an organization is channeled into a common data base to serve the information requirements throughout the organisation. It is termed as integrated System.

Answer to Question 15 :

(a) An **interface device** is a device for communication between computer and human beings. Three such devices are

Mouse : This is the most common interface device on PCs. It has a rubber ball at the bottom and two or three switches at the top. When the mouse is moved on the desktop or on a pad, the pointer on the computer (mouse pointer) also moves on the screen of the computer. The rubber ball provides the movement of direction and a click on a switch on the mouse triggers action command to the computer.

Trackball : This is similar to the mouse. The difference is that unlike the mouse the trackball is fixed on a case on the computer (usually on the base of the computer). The trackball is more common in portable computers.

Joystick : With this, moving a lever on the base of computer carried out the movement of the pointer on the computer.

Cursor : It is a communication device between the user and the machine.

(b) **DSS :** Decision Support System,

MODEM : Modulator Demodulator

SDLC : System Development Life Cycle,

EDI : Electronic Data Interchange.

(c) The basic **components of a compute**r are –

» Input device (e.g. Mouse, Keyboard etc.)

» Processing Unit consisting of Memory, Arithmetic / Logic Unit and Control Unit.

» Output device (e.g. printer).

For Internet surfing or e-mailing, the additional units that will be required are (i) Modem (ii) Telephone Line (c) Browser software like Internet explorer or Netscape Navigator. In addition, one will have to subscribe to an Internet Service Provider (ISP).

Computer	—	Modem	—	Telephone	—	ISP

Answer to Question 16 :

(a) All software irrespective of how well it has been designed and developed and irrespective of whether it is an ERP or any other packaged software requires maintenance over its life time. Maintenance of information systems means enhancement modifications and corrections to the software. There are several reasons why all information systems need maintenance viz.

- Changing business environment.
- Changes in users' expectations.
- Changes in technology.
- Deterioration in software quality due to patches over time
- For time savings.

(b) ***(i)*** ***Multiprocessing*** is the term use to describe a processing approach in which two or more independent processors are linked together in a coordinated system. In such a system, instructions from different and independent program can be processed at the same instant in time by different processor. The processors may simultaneously execute different instruction from the same program.

(ii) ***Distributed Data Processing (DDP)*** is a system in which the computing and other resources are decentralized instead of being located at just one place. The points at which the resources are located are interconnected and although may act autonomously at times also at cooperatively in handling common problem.

A *DDP* system therefore has a number of characteristics :

(i) Computer hardware and user are decentralised.

(ii) There is some form of communication linkage between location where the computer resources and user are situated.

(iii) Users tend to have responsibility for there own data and data processing - they tend to 'own' their system.

(iv) When the system is not operating as a whole, quite often some data processing can continue locally at individual user sites.

(c) (i) False , (ii) True , (iii) True , (iv) False.

Answer to Question 17 :

(a) Five types of commonly used business graphs are :

- Column Chart.
- Bar Chart
- Line Chart
- Pie Chart
- Stacked bar Chart.

(b) (i) ***Electronic Commerce*** refers to the business by way of sale of goods and provision of services transacted electronically over the Internet. It is an on-line approach to conducting business with customers including advertising marketing order entry and processing, payment, and customer support. The Internet is an open system and the users can hardly be traced. Important features of e-business are :-

Five types of commonly used business graphs are :–

» Electronic signature.

» Cryptography

» Authentication and

» Certification.

(ii) ***E-money*** refers to the digital version of currency and exchange. Digital money moves through a multiplicity of networks rather than via current banking system. Electronic currency substitutes for money on on-line transaction, including secured credit cards, electronic cheques and digital coins.

(iii) ***E-mail*** is system that enables a person to compose a message on a computer and transmit it through a computer network to another computer user.

(iv) ***Webmaster*** is the individual responsible for maintaining and updating the content of a World Wide Web document. Webmasters are the creative force behind the World Wide Web.

(v) ***Yahoo !*** It is one of the most popular website having lot of facilities like Browsing, E mail, Chat etc. It also have a search Engine

(vi) ***The Information highway*** refers to the interconnected series of networks that provides the infrastructure for transporting information throughout the world.

Answer to Question 18 :

(a) A *code* consists of a number of digits to denote a specific entity. Thus a lengthy description may be expressed by unique code, which facilitates designing input documentation, and computerised processing. Even in a manual system, use of codes are useful in day-to-day transaction and communication e.g. work order no., sales invoice no., purchase order no., form no. etc. Employees may have identification no./ ticket no./ employee no. and selected few letters from the name. Thus employee no. may be matched with the selected letters for validation process for the sake of accuracy. There are other methods of validation process also. Codes representing major key fields are matched between the master file and the transaction file in a computerised environment for data processing purpose.

A good coding system should have the following characteristics :

- Each code should be unique, compact and meaningful.
- Size of the code should be precise, and of fixed length with flexibility to facilitate insertion or expansion as may be envisaged.
- A code of a major key field may have a check digit embedded in it to ensure accuracy of processing.
- Codes should consist of numeric digits as much as possible to facilitate validation and faster processing.

The following three methods of structuring codes are more commonly used :

- ***Sequential Code :*** Codes are allotted as consecutive numbers to data entities e.g., employee number, invoice number, purchase order no., bill no. etc.
- ***Block Code :*** Under this method, entities are classified into groups and blocks of numbers are assigned to each group. The block size depends on number of items expected to be in use in the classified groups with flexibility for future insertion/exception. For example, an organisation with 7000 employees may have a 5-digit employee number where the left most digit may indicate category of employees viz., 1 for officers, 2 for supervisors, 3 for clerical staff and 4 to 9 for workmen. The right most digits may be reserved for check digit. Thus a block of 1000 numbers are reserved for each of the three categories of officers, supervisors, and clerks and rest 6000 numbers for workmen (first 1000 numbers beginning with left most ')' are left unallotted at present).
- ***Bar Code :*** Such codes are popular in companies running departmental stores and consist of vertical line of various thickness to represent digits 0-9. The code identifies the product, the manufacturer, and the price of the product on which it is affixed. The line symbols are easily read by the computer and converted into numbers that represent the code. One of the popular methods is UPC or Universal Product Code.

(b) A ***master file*** contains information of semipermanent nature e.g. employee number, name, address, date of birth, date of appointment, designation, scale of pay etc. Such a file is called employee master file. Insertion, deletion and modifications in the fields are carried out regularly to keep the master file updated. Payroll processing is dependent on both the master file and the transaction file accessed simultaneously.

A ***transaction file*** is of temporary nature and contains records of current transactions that are variable in nature from period to period e.g. stores receipts and issues during a period. Such transaction file together with the master file are used for updation of master files and giving printouts for various users.

(c) Sorting constitutes arranging records in a file in either ascending or descending order of a key field. Merging involves combining two or more fields into a single file considering one or a combination of key fields as the sequence number. Sorting and merging is an essential element of data processing activity.

Answer to Question 19 :

(a) (i) Memory cycle time.

(ii) Storage Capacity

(iii) Number of data transfer channels

(iv) Range of multi-programming capability

(v) Real time processing capacity

(b) (i) – (d)

(ii) – (g)

(iii) – (f)

(iv) – (c)

(v) – (a)

(vi) – (h)

(vii) – (e)

(viii)– (b)

(ix) – (j)

(x) – (i)

(c) **URL** is the acronym of **Uniform Resource Locator.** It contains information about the location of a document. When a user clicks on a link, the URL provides the information about the link to the browser. It assists in implementing any link from one document to another.

(d) Protocol refers to computer software that handles transmission between computers and allows computers to communicate. It is a set of standards defining the procedure and the format for data to be transmitted via communication links.

Answer to Question 20 :

(a) 'Digital signature' means authentication of any electronics record by a subscriber by means of an electronic method or procedure.

Digital signature is created by using a hash result which is unique to both the signed message and a given private key. For the hash result to be created there must be only negligible possibility that the same digital signature could be created by the combination of any other message or private key.

Digital signature is verified by the process of checking the digital signature by reference to the original message and a given public key and determining whether the digital signature was created for that same message using the private key that corresponds to the referenced public key.

(b) ***(i)*** ***False.*** The System Analyst is concerned with analysing the existing system and preparing specifications for the proposed system, which are passed on to the System Designer for detailed designing.

(ii) ***False.*** Generally lower level management deal with structured problems. Middle level is concerned with tactical planning while top level management deal with strategic planning and control having nature of unstructured or semi-structured problems.

(iii) ***False.*** Data pertain to raw facts that are assembled, analysed and summarised to produce information, which is meaningful for the recipient.

(iv) ***True.*** BIT is an abbreviation of Binary Digit consists of 0 and 1. Byte is a combination of 8 bits, which represents either an alphabet, digit or any special character.

(v) ***False.*** Primary or main storage is a section of the CPU while secondary storage holds data outside the CPU. The CPU handles the secondary storage like any other input-output peripherals and can access data in the secondary storage only when the same are brought into the main memory. So, we can say that, the data stored within the secondary storage are dumb data and that when transferred to the main memory become live data.

Answer to Question 21 :

(a) **(i)** **Manufacturing :**

(i) An order schedule (to hold shipping schedules, manufacturing and delivery schedules, for each order)

(ii) A sub-assembly pole (listing all intermediate assembles for final products)

(iii) A price list file (listing all component required by each assembly), and

(iv) An availability file (containing information about availability of all the required components and sub-assemblies).

(ii) **Marketing :**

(i) Order filing (including order entry shipping and billing)

(ii) Order getting (sales promotion, customer relations, advertising)

(iii) Information and analysis

(iv) Planning (using techniques such as forecasting, simulation etc.)

(iii) Finance and Accounting :

(i) Logistics-related activities

(ii) Collection and dissemination of financial information

(iii) Analytical activities

(iv) Share accounting

(v) Budget and finance planning

(vi) Tax planning

(vii) Resource mobilisation

(b) Three principal methods of creating databases are :

(i) ***Hierarchical (or tree) databases :*** In this type of database, records are arranged in the construction of an organisation chart, i.e., an inverted tree in which the top record may be viewed as the root, with the next level having several nodes (or child records), with the child record becoming a parent for the records (nodes) at the next level, and so on. When a parent record has no child, the latter is termed as a leaf.

(ii) ***Network Database :*** This is also a kind of hierarchical database but with certain differences. In this type of database each node (or child) may have several parents. The nodes are interconnected in a multidimensional manner by means pointers which are established by using one of the fields in each record to contain address of the physical medium of the next record in a logical sequence. DBMS software makes it possible to reach any node for the purposes of data retrieval.

(iii) ***Relational Database :*** The relational structure is the most popular, (particularly with PCs), and is, possibly, the most flexible type of data organization for database construction. This type of database is built around the concept that data contained in the conventional files can, with some duplication, be transformed into two dimensional tables. Each such table may have any number of rows, but may have only few columns. Data in each column has to be of uniform size, residing a field in a record, for example customers' name.

(c) Types of Databases by ownership criteria are :

(i) Individual databases

(ii) Company (or shared databases)

(iii) Distributed databases

(iv) Proprietary databases.

Answer to Question 22 :

(a) ***Knowledge-based system*** is a software developed around facts and generally accepted rules for performing specialized tasks. Human intelligence duplicated in such systems are of surface type and are not of very complex in nature.

An expert system, on the other hand, is also a knowledge -based system. But, it is developed around Artificial Intelligence to capture deep knowledge and expertise in particular field.

(b) The term ***Database Management System*** or **DBMS** is applied to a specialised kind of software that makes it possible to create and modify a database and allows access to the data stored in the database. It essentially consists of two parts viz. Data Dictionary and Query Language. The data dictionary describes structure of data in the database and also the characteristics of data viz. length, type etc. The query language part provides access to data in the database. It also helps generate reports.

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Answer to Question 23 :

(a) A Parcel carrying transport company will be having the data on :

(i) Bookings

(ii) Expenses

(iii) Operations

(iv) Accounts

(v) Petty Cash expenses

(vi) Claims

(vii) Complaints

(viii) Delivery

(ix) Maintenance, and so on.

The specimen format is given for booking figures.

Sl. No.	Waybill No.	Commodity	Qty (Unit)	Freight	Remarks

They will also be collecting the data as on date and cumulative figures for which provisions can be made. Similarly for each item the format can be suitably devised.

(b) The head office can collect the data branch wise and then collate for all branches and obtain the figures for the draft and cumulative as required.

Branch	Booking for the date	Cumulative Booking for the month	Cumulative Booking for the previous month
1			
2			
3			
4			

The software can be suitably devised and the data can be sent by modern/other electronic media depending upon the available resources. Similarly the other data can be compiled.

(c) If the computers are made available at the branches and the head office the communication can be fast and the uniformity in formats an required data can be standardised.

If the personnel are suitably trained than they will be finding it comfortable to send the required information on time.

The head office will collate all the branch data quickly and carry out the various analysis and submit to the top management for quick decisions.

Using the software the results can be obtained in Tabular forms and or graphical devices.

When Quantitative Techniques are applied the results are used for quick decisions

Any correction a changes can be introduced and revised results can be obtained.

(d) The following precautionary measures can be taken to prevent possible errors :

(i) The personnel who are involved in collection of data should be sufficiently trained so that the source data are correct.

(ii) Data entry operators/staff should be trained in entering the data in the computer.

(iii) Source data can be linked to modem/other electronic media to prevent duplication of entry/ copy of data.

(iv) The persons similarly who receive the data as the head office should be trained in connecting each branch and collate the data.

(v) Each computer should be provided with back up in case of failure of electricity.

(vi) Passwords are to be used by these personnel so that there is no problems of whatsoever

(viii) The security for computers, disasters and misuse of computers should be avoided.

Answer to Question 24 :

(a) **Advantages of Centralised Architecture :**

(i) Hardware setup for this architecture is less expensive.

(ii) This system provides us all the data related to the entire company. Hence, at any point of time we can fetch any data from a single point.

(iii) We can get the consolidated MIS report much faster.

(iv) Overall control on operations is much compact

(v) Database administration is centralized, hence tampering is not possible.

Disadvantages of Centralised Architecture :

(i) Network setup is very expensive and its maintenance cost is also very high.

(ii) If the network system breaks down then the entire system will be handicap.

Advantages of Decentralised Architecture :

(i) It is an efficient and prompt processing of jobs assigned to different processor.

(ii) The system can be easily expanded as per requirement, by addition of more units as required.

(iii) At any particular point we can get, to the point report for a specific data.

(iv) If any network hazard occurs, the system can run smoothly because the operation can be done from various points.

(v) Failure of one particular system does not, seriously, affect working of the entire system.

Disadvantages of Decentralised Architecture :

(i) Hardware setup is expensive.

(ii) Consolidate MIS generation is cumbersome

(iii) Database administration is decentralised hence tampering chance is higher.

(b) **Some hazards of computerisation are :**

(i) Machine breakdown (due to some hardware parts problem)

(ii) Due to virus infection data even can be destroyed

(iii) Due to incompetence of staff the software can be erased from the machine and the data can be corrupted.

(iv) Purposefully any body can damage the system or data can be tampered.

Some of the measures to avoid these hazards are :–

(i) Regular backup of the entire company data

(ii) The computer should be protected from unauthorised user by restrictions on physical entry and it should be password protected, so that, the system can not be started by any unauthorised person.

(iii) The second level of password checking should be done by the software itself which is running for the computation job.

(iv) Data encryption

(v) Regular virus scanning and virus removal

(vi) Proper method of data recovery and database recreation.

(vii) Contingent planning.

(c) **The steps involved in program development are :**

(i) Defining objective

(ii) Specifying input and output formats

(iii) Designing program logic

(iv) Selecting programming language

(v) Coding (writing) program

(vi) Compiling program for detecting syntax errors and logical errors in the source program.

(vii) Testing and debugging of programs

(vii) Documentation.

Answer to Question 25 :

(a) **The techniques for changing over from the old system to new system are** :

(i) Direct changeover from the old one to the new one.

(ii) Both systems are running parallely for some time (until and unless the new system is proved as full proof).

(iii) Pilot running.

(iv) Phased Changeover.

(b) ***Data processing :*** Data processing is basically concerned with converting raw data into well-ordered information as would serve the purpose of the recipient. Data processing activities, in turn, encompass data input, data manipulation and outputting results of data manipulation.

Components of Computerised Data Processing system :

(i) ***Hardware:*** Electronically-operated machines for carrying different operations.

(ii) ***Software :*** Step-by-step instructions that tell the computer how to do its work.

(iii) ***Procedures :*** These relate to the routines to be followed in such matters as preparation of data, operation of computer, distribution of the processed output and the like.

(iv) ***Personnel:*** Computer installations employ the following types of personnel

(a) System Analyst

(b) Programmers

(c) Operators

(v) **Data**

(c) **Controls on computer outputs :**

(i) Initial screening of outputs

(ii) Reconciliation of output control totals

(iii) Immediate distribution of outputs

(iv) Systematic manual checks.

Answer to Question 26 :

(i) **Introduction :**

- Overview of the company.

- Operations in various units and offices with future plans
- Current information technology with special emphasis on WWW and internet.
- Financial Accounting and costing system followed.
- Present audit coverage.

New computerised system :

- Hardware, Networking, technologies for data transmission, system software, file structure and processing techniques.
- Basic concept of e-mail, Internet, WWW and E-commerce
- Information system designed.
- Codification.
- Input-output documentation
- Data communication system
- Decision Support System

Control and Audit of computer based system :

- Overview.
- Changes in accounting and auditing environment brought about by computers.
- Control system
- Input controls
    - Processing controls
    - Output controls
    - Internal controls
    - Security controls

Auditing in computer based data processing system :

- Introduction
- Understanding basic features of the computer based system
- Review of application documentation
- Evaluation of controls
- Designing test procedures
- Application of selected audit procedures to critical controls
- Analysis of audit results and reporting

(ii) The guidelines to conduct the audit of computerised accounting system will comprise the following steps :

- Understanding basic features of the computer based system
  - Input documentation
  - Accounting system
  - MIS
  - Control system
- Review of application documentation
  - Data contents
  - Procedures
  - Internal controls
  - System flowchart
  - Input formats
  - Record layouts
  - Coding system
  - Exceptions
  - Evaluation of control
  - Preparation of control checklist
  - Appraisal of key activities
  - Designing test procedures
  - Choosing testing techniques
  - Testing processing operations
- Using computers as audit tools
  - Test deck
  - Generalized audit programme
- Preparation of audit program
  - Compliance test
  - Evaluation of audit results
- Reporting to management

(iii) Auditing around the computer requires the following steps :

(a) Selection of one or more critical output from the computer system.

(b) Verifications of the results exhibited by the output to ascertain correctness and completeness of the transactions processed.

(c) Audit trail to locate the original source of input for verification

Auditing through the computer implies verification of the computerized system itself and its efficacy to produce the correct and required output.

Answer to Question 27 :

End of year	Operational Costs (in Rs. lakhs) Old system (a)	New system (b)	Difference (a–b)	Cumulative difference of operational Cost
1	25	55	–30	–30
2	28	38	–10	–40
3	34	14	–20	–60
4	45	15	30	–30
®X				¬
5	47	16	31	01

Pay-back period lies between 4th and 5th year. Let 'X' be the pay-back period, where cumulative operational cost is 'Zero'.

$$\therefore \quad \frac{x-4}{5-4} = \frac{0+30}{1+30} \quad \text{[By simple Interpolation Formula]}$$

or, x–4 = 30/31 ; *or,* x = 4 + 0.97 = 4.97 years = 4 years 11.5 months (approx.)

Hence, Pay back period is 4 years 11.5 months. Hence, the management will recover all of its initial cost and start making profit after that period.

(b) Software quality essentially means that it is error-free and satisfies the users needs. Specifically, it means Suitability and Maintainability.

Suitability implies reliability, correctness, accuracy, understandability, modifiability, traceability, portability and reusability.

The main tools for Quality Assurance of Software are -

(i) Development, Process itself,

(ii) Reviews,

(iii) Audits,

(iv) Testing and Matrices.

(c) **System Changeover:**

System Changeover means a process of changing old system to new system. When the programming, creating of database, installation of necessary equipment and user training for the new system is complete then, the old system can be replaced by the new system. The method and style of the new system will reflect the users response and attitude to the system.

There are three methods of System Changeover :–

(i) ***Crash Method :*** Here the old system will be discontinued and new system will be implemented.

(ii) ***Parallel Method :*** Here the old system as well as new system will run in parallel for a period until it works to the satisfaction of all concerned.

(iii) ***Staged Method :*** Here the old system is replaced by the new system gradually by stages.

Answer to Question 28 :

(a) The World Wide Web or **www** as it is called is a concept based on the internet technology. It is a concept that provides the technology to navigate the vast resources available on the internet. The concepts of hypertext, internet and multimedia are integral to the concept of www. The word 'web' in the www signifies the ability to navigate through the multitude of computers and access texts, graphics, sound files etc. in a web-like fashion.

Internet is the network of hundreds or thousands of computers and computer networks worldwide, which are connected with each other, exchanging information. The network is not controlled by central authority or organisation. Instead of data going to a central computer and then to its destination with Internet, the data has many points to go from one computer to another, over a web of computers.

www is a concept while Internet is the physical aspect of it.

(b) **Calculation of Record Size :**

Field Name	**Maximum Field Size**
Purchase-order-number	6
Vendor code	3
Order-quantity	5
Order-date	6
For record deletion Marker	1
Therefore, Record Size	21

Calculation of File Space Requirement :

Record Size	21
× Maximum expected records	750
= Required Record Space	15750
+ 15% increase in future (15% of 15750)	2363
	18113
+ 20% overhead (20% of 18113)	3623
	21736
+ 10% contingency (10% of 21736)	2174
Therefore, File Space Required	23910
[For overflow conditions]	

(c) File Retention:

File Retention is the process of permanent storage of data. It can be done into two categories of devices - Random and Sequential. Random devices allow access to information directly and not in the order in which they are stored. Whereas in sequential devices storage and retrieval has to be done in the same order.

File Recovery:

It is the process of retrieval of data which has been partially corrupted due to logical or physical errors on the storage media. It is done using certain third party utilities.

Answer to Question 29 :

(a) ***Data integrity* :** Concerns about errors, duplicity and inconsistencies of data.

***Security* :** Security refers to the protection of data from unauthorised access and use which could damage organisational interest.

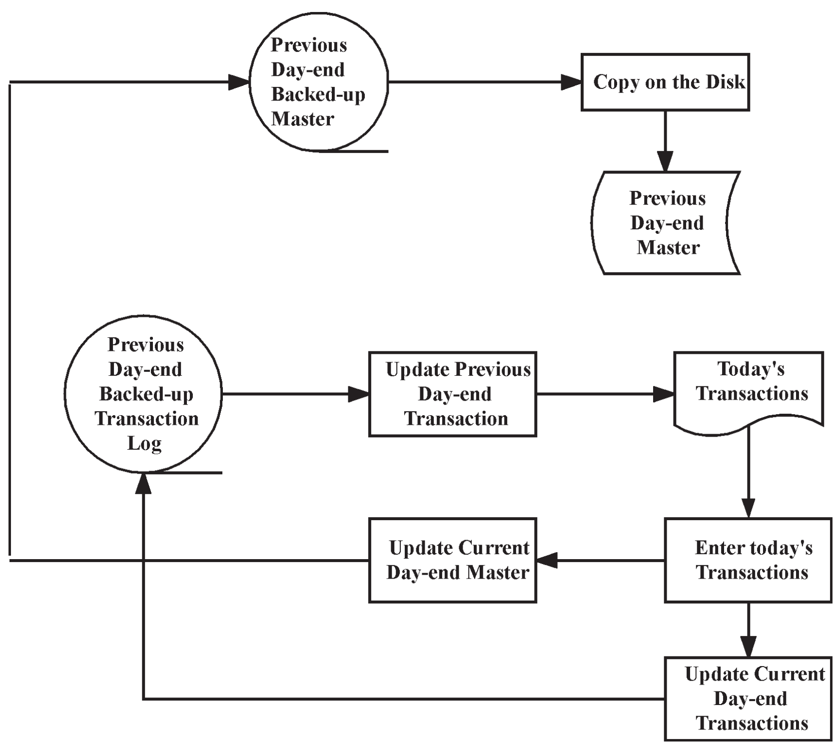
***Privacy* :** Privacy refers to unauthorised access and use of data which could damage individuals interest.

(b) **Structured and Unstructured Decisions:**

A structured decision is a random one and is made on the basis of certain pre-planned actions. An unstructured decision is non-routine in nature and is infrequent.

Structured decisions follow certain predetermined logical steps and are programmable. But, unstructured decisions are not amenable to programming.

(c)



Answer to Question 30 :

(a)

Type of S/W	*Advantages*	*Disadvantages*
Buying readymade	1. Can be seen and tested 2. Will have fewer bugs 3. May be less costly 4. Implementation time saving 5. Documentation/help facilities	1. May not meet requirements fully 2. Enhancements/modifications may be expensive and time consuming 3. Requires development, testing and implementation time
Built by outside firm	1. Better control over schedule and cost 2. Does not affect day to day operations due to development work 3. Ready skills when new h/w or s/w platforms	1. Difficult to negotiate on effort and time required 2. Difficult to implement without adequate technical knowledge of the software. 3. Difficult to maintain after implementation 4. Unfamiliarity of the outside party with business may hamper quality
Built-in-house	1. Familiarity with business will lead to better quality 2. Will meet requirements fully 3. Development of in-house skills 4. May make money by selling the software	1. Difficult to adhere to time schedule. 2. Additional manpower cost 3. Particular skills may not be available 4. Improvisation according to systems followed by others.

(b) Prototyping is the process of quickly building a model of the final application system. It is primarily used as a means of understanding and communicating the requirements of the users.

Advantages of Prototyping include faster development time, easier end-user learning, better functionality of the software, better communication between users and analysts. The disadvantages include fostering of undue expectations of users, providing users with something that may not get finally.

The two types of Prototyping approach are (i) Iterative (ii) Throwaway. In iterative type approach, the prototype is developed, demonstrated to users and modified based on users feedback. This process is continued till the prototype evolves into a final system which get implemented.

In throwaway approach, the prototype is only a model of the final system. It is not what is implemented. Once the prototype satisfies the users, a new system is developed based on the same.