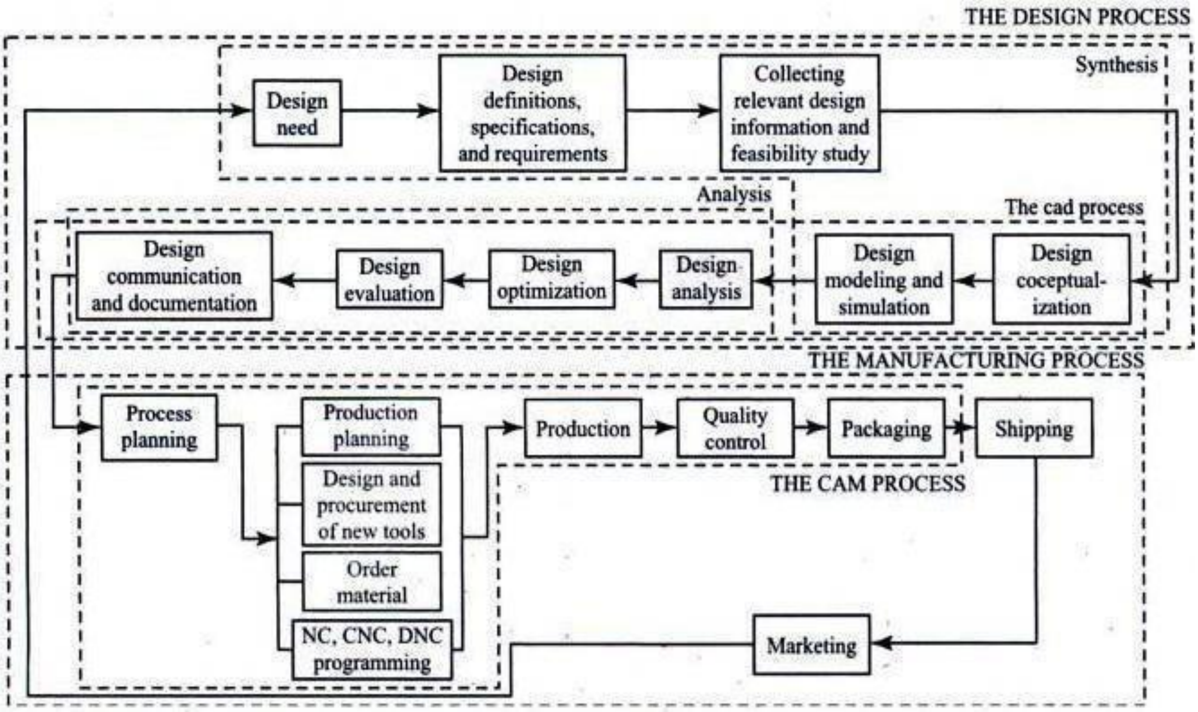
# UNIT – I
# Fundamentals of CAD CAM

## INTRODUCTION

- In engineering practice, CAD/CAM has been utilized in different ways by different people.
- Some utilize it to produce drawings and document designs.
- Others may employ it as a visual tool by generating shaded images and animated displays.
- A third group may perform engineering analysis of some sort on geometric models such as finite element analysis.
- A fourth group may use it to perform process planning an generate NC part programs. In order to establish the scope and definition of CAD/CAM in an engineering environment and identify existing and future related tools, a study of a

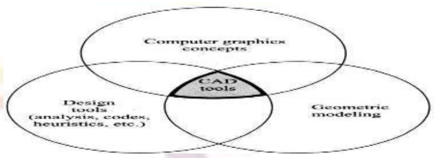



typical product cycle is necessary. Figure 1.1 shows a flowchart of such a cycle.

*Fig. 1.1 Typical Product Cycle*

- CAD tools can be defined as the intersection of three sets: geometrical modeling, computer graphics and the design tools.

- Figure 1.2 shows such definition. As can be perceived from this figure, the abstracted concepts of geometric modeling and computer graphics must be applied innovatively to serve the design process.
- Based on implementation in a design environment, CAD tools can be defined as the design tools (analysis codes, heuristic procedures, design practices, etc.) being improved by computer hardware and software throughout its various phases to




achieve the design goal efficiently and competitively as shown in Fig. 1.2.

*Fig. 1.2 Definition of CAD tools based on their Constituents*

- Designers will always require tools that provide them with fast and reliable solutions to design situations that involve iterations and testings of more than one alternative.
- CAD tools can vary from geometric tools, such as manipulations of graphics entities and interference checking, on one extreme, to customized applications programs, such as developing analysis and optimization routines, on the other extreme.
- In between these two extremes, typical tools currently available include tolerance analysis, mass property calculations and finite element modeling and analysis.

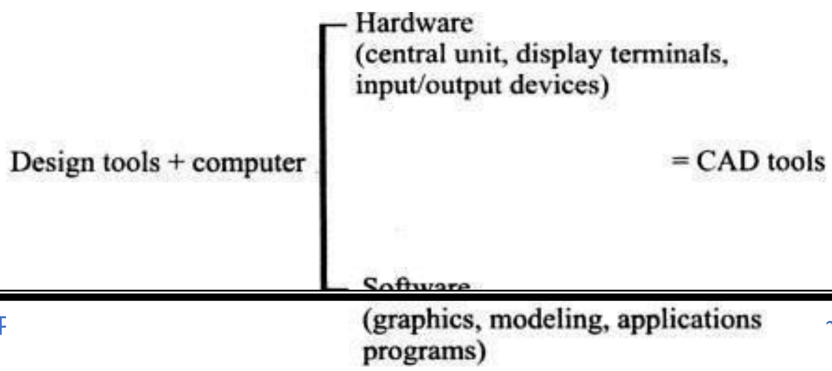


*Fig. 1.3 Definition of CAD tools based on their implementation in a design environment*

CAD tools, as defined above, resemble guidance to the user of CAD technology.

- The definition should not and is not intended to, represent a restriction on utilizing it in engineering design and applications. The principal purposes of this definition are the following:

  1. To extend the utilization of current CAD/CAM systems beyond just drafting and visualization.
  2. To customize current CAD/CAM systems to meet special design and analysis needs.
  3. To influence the development of the next generation of CAD/CAM systems to better serve the design and manufacturing processes.

## Reasons for Implementing a CAD System

**1. To increase in the productivity of the designer**

The CAD improves the productivity of the designer to visualize the product and its components, parts and reduces time required in synthesizing, analyzing and documenting the design.

### 2. To improve the quality of design

- CAD system permits a more detailed engineering analysis and a large no. of design alternatives can be investigated.
- The design errors are also reduced because of the greater accuracy provided by system.

### 3. To improve communication in design

The use of a CAD system provides better engineering drawings, more standardization in drawing, better documentation of design, few drawing errors.

### 4. To create a data base for manufacturing

In the process of creating the documentation for the product design, much of the required data base to manufacture the product can be created.

### 5. Improves the efficiency of design

It improves the efficiency of design process and the wastages at the design stage canbe reduced.

**Conventional Design Process**

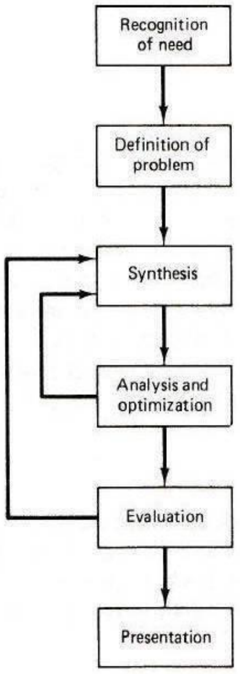



*Fig. 1.4. Conventional Design process*

There are six steps involved in the conventional design process as discussedbelow:

## 1. Recognition of need

- The first step in the designing process is to recognize necessity ofthat particular design.
- The condition under which the part is going to operate and theoperation of part in that particular environment.
- The real problem is identified by knowing the history and difficulties faced in system.

## 2. Definition of problem

- The design involves type of shape of part, its space requirement, the material restrictions and the condition under which the part has to operate.
- The basic purpose of design process has to be known before starting the design.
- A problem may be design of a simple part or complex part.
- It may be problem on optimizing certain parameters.

### 3. Synthesis of design

- In this, it may be necessary to prepare a rough drawing of design part.
- The type of loading conditions imposed on the parts.
- The type of shapes which the part section can require and approximate dimension at which the different forces are located has tobe provided on the sketch of part.
- The stresses to which the part is likely to be subjected must be analyzed and relevant formulas should be prepared.
- A mathematical model of design may be prepared to synthesize the parts of design.

### 4. Analysis and optimization

- The design can be analyzed for the type of loading condition as well asthe geometric shape of the part.
- In the first stage it will be necessary to check the design of the part forsafe stresses.
- If it is not satisfactory, then the dimensions of the part can berecalculated.
- The part can further be optimized for acquiring minimum dimensions,weight, volume, efficiency of the material and cost.
- The optimization depends on the definition of the problem and importance of a parameter.
- It may be sometimes necessary to optimize the part for certainoperating parameters like efficiency, torque, etc.

### 5. Evaluation

- It is concerned with measuring the design against the specificationsestablished in the problem definition phase.
- The evaluation often requires the fabrication and testing of model toassess operating performance, quality and reliability.

### 6. Presentation

- The design of component must be presented along with necessarydrawings in an attractive format.

## 1.4 Conventional Design vs CAD

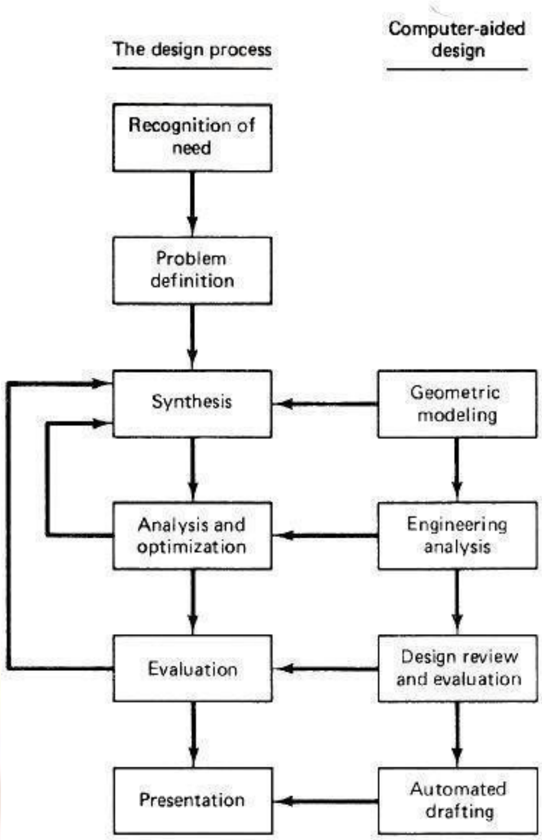



*Fig. 1.5 Computer Aided Design*

### 1. Geometric modeling

- Geometric modeling is concerned with the computer compatible mathematical description of the geometry of an object.
- The mathematical description allows the image of the object to be displayed and manipulated on a graphics terminal through signals from the CPU of CAD system.
- The software that provides geometric modeling capabilities must be designed for efficient use both by the computer and human designer.
- The basic form uses wire frames to represent the object.
- The most advanced method of geometric modeling is solid modeling in three dimensions.

### 2. Engineering Analysis

- The analysis may involve stress-strain calculations, heat transfer computation etc.

- The analysis of mass properties is the analysis feature of CAD system that has probably the widest application.
- It provides properties of solid object being analyzed, such as surface area, weight, volume, center of gravity and moment of inertia.
- The most powerful analysis feature of CAD system is the finite element method.

### 3. Design Review & Analysis

- A procedure for design review is interference checking.
- This involves the analysis of an assembled structure in which there is a risk that the components of the assembly may occupy same space.
- Most interesting evaluation features available on some CAD systems is kinematics.
- The available kinematics packages provide the capabilities to animate the motion of simple designed mechanisms such as hinged components and linkages.

### 4. Automated Drafting

- This feature includes automatic dimensioning, generation of cross-hatched areas, scaling of the drawing and the capability to develop sectional views and enlarged views of particular part details.

## Benefits of CAD

## Limitations of CAD

- Improved engineering productivity
- Reduced manpower required
- More efficient operation
- Customer modification are easier to make
- Low wastages
- Improved accuracy of design
- Better design can be evolved
- Saving of materials and machining time by optimization
- Colors can be used to customize the product

- The system requires large memory and speed.
- The size of the software package is large.
- It requires highly skilled personal to perform the work.
- It has huge investment.

## CAD/CAM Systems Evaluation Criteria

- The various types of CAD/CAM systems are Mainframe-Based Systems, Minicomputer-Based Systems, Microcomputer-Based Systems and Workstation Based Systems.
- The implementation of these types by various vendors, software developers and hardware manufacturers result in a wide variety of systems, thus making the selection process of one rather difficult. CAD/CAM selection committees find themselves developing long lists of guidelines to screen available choices.
- These lists typically begin with cost criteria and end with sample models or benchmarks chosen to test system performance and capabilities. In between comes other factors such as compatibility requirements with in-house existing computers, prospective departments that plan to use the systems and credibility of CAD/CAM systems' suppliers.
- In contrast to many selection guidelines that may vary sharply from one organization to another, the technical evaluation criteria are largely the same. They are usually based on and are limited by the existing CAD/CAM theory and technology. These criteria can be listed as follows.

## System Considerations

### (i) Hardware

Each workstation is connected to a central computer, called the server, which has enough large disk and memory to store users' files and applications programs as well as executing these programs.

### (ii) Software

Three major contributing factors are the type of operating system the software runs under, the type of user interface (syntax) and the quality of documentation.

### (iii) Maintenance

Repair of hardware components and software updates comprise the majority of typical maintenance contracts. The annual cost of these contracts is substantial (about 5 to 10 percent of the initial system cost) and should be considered in deciding on the cost of a system in addition to the initial capital investment.

### (iv) Vendor Support and Service

Vendor support typically includes training, field services and technical support. Most vendors provide training courses, sometimes on-site if necessary.

## Geometric Modeling Capabilities

### (i) Representation Techniques

The geometric modeling module of a CAD/CAM system is its heart. The applications module of the system is directly related to and limited by the various representations it supports. Wireframes, surfaces and solids are the three types of modeling available.

### (ii) Coordinate Systems and Inputs

In order to provide the designer with the proper flexibility to generate geometric models, various types of coordinate systems and coordinate inputs ought to be provided. Coordinate inputs can take the form of cartesian (x, y, z), cylindrical (r, θ, z) and spherical (θ, φ, z).

### (iii) Modeling Entities

The fact that a system supports a representation scheme is not enough. It is important to know the specific entities provided by the scheme. The ease to generate, verify and edit these entities should be considered during evaluation.

### (iv) Geometric Editing and Manipulation

It is essential to ensure that these geometric functions exist for the three types of representations. Editing functions include intersection, trimming and projection and manipulations include translation, rotation, copy, mirror, offset, scaling and changingattributes.

### (v) Graphics Standards Support

If geometric models' databases are to be transferred from one system to another, both systems must support exchange standards.

**Design Documentation**

## (i) Generation of Engineering Drawings

After a geometric model is created, standard drafting practices are usually applied to it to generate the engineering drawings or the blueprints. Various views (usually top, front and right side) are generated in the proper drawing layout. Then dimensions are added, hidden lines are eliminated and/or dashed, tolerances are specified, general notes and labels are added, etc.

**Applications**

### (i) Assemblies or Model Merging

Generating assemblies and assembly drawings from individual parts is an essential process.

### (ii) Design Applications

There are design packages available to perform applications such as mass property calculations, tolerance analysis, finite element modeling and analysis, injection modeling analysis and mechanism analysis and simulation.

### (iii) Manufacturing Applications

The common packages available are tool path generation and verification, NC part programming, postprocessing, computer aided process planning, group technology, CIM applications and robot simulation.

### (iv) Programming Languages Supported

It is vital to look into the various levels of programming languages a system supports. Attention should be paid to the syntax of graphics commands when they are used inside and outside the programming languages. If this syntax changes significantly between the two cases, user confusion and panic should be expected.

**CAD Hardware**

The hardware of CAD system consists of following:

- CPU
- Secondary memory
- Workstation
- Input unit
- Output unit
- Graphics display terminal

### 1. Central Processing Unit (CPU)

The CPU is the brain of the entire system.

## Functions of CPU

- To receive information from the work station and display the output on the CRT screen.
- To read the data stored in the secondary memory storage unit.

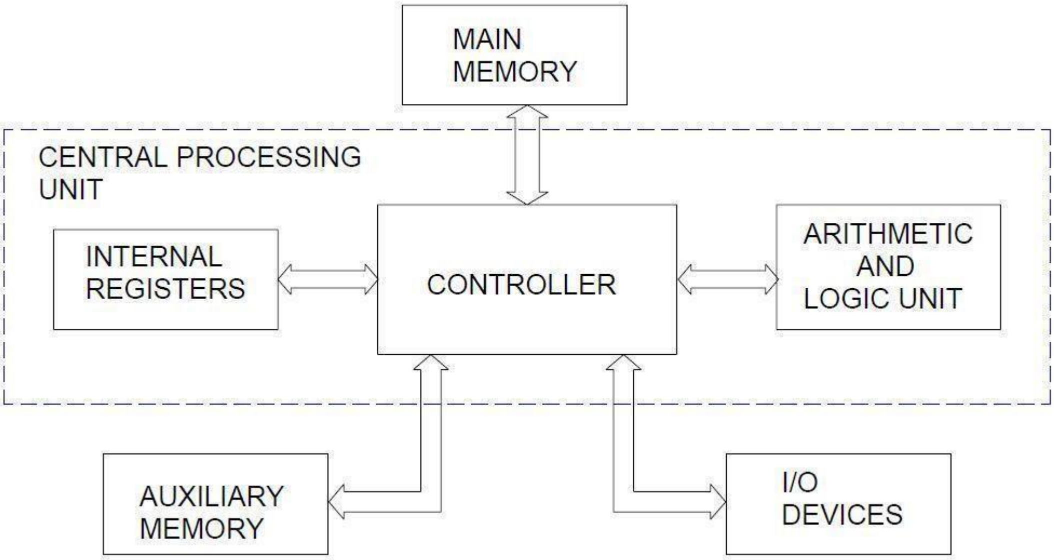



*Fig. 1.6 Components of CPU*

## Functions of secondary memory

- To store files related to engineering drawing
- To store programs required to give instruction to output devices like plotters.
- To store CAD software
- The secondary storage unit consists of magnetic tapes and discs.

## 2. Work Station

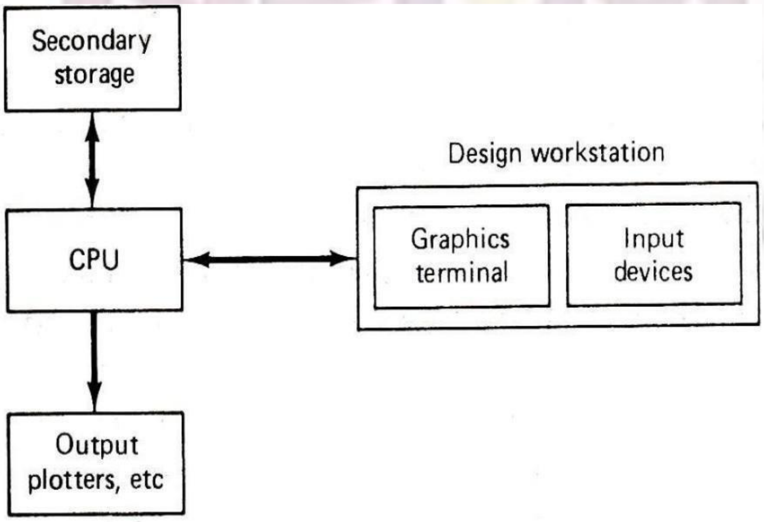



*Fig. 1.7 Design Workstation*

• The work station is a visible part of the CAD system which provides interaction between the operator and the system.

• Among these advantages offered by work station are their availability, portability, the availability to dedicate them to a single task without affecting other users and theirconsistency of time response.

• A work station can be defined as a station of work with its own computing power to support major software packages, multitasking capabilities demanded by increased usage, complex tasks and networking potential with other computing environments.

## 3. Input Devices

- A no. of input devices is available. These devices are used to input two possible types of information: text and graphics.
- Text-input devices and the alphanumeric keyboards.
- There are two classes of graphics input devices: Locating devices and image input devices.
- Locating devices, or locators, provide a position or location on the screen.
- These include light pens, mouse, digitizing tablets, joysticks, trackballs, thumbwheels, touchscreen and touchpads.
- Locating devices typically operate by controlling the position of a cursor on screen. Thus, they are also referred to as cursor-control devices.

### I. Scanners

- Scanners comprise other class of graphics-input device.
- There are four relevant parameters to measure the performance of graphics input devices. These are resolution, accuracy, repeatability and linearity.
- Some may be more significant to some devices than others.

### II. Keyboards

- Keyboards are typically employed to create/edit programs or to perform word processing functions.
- CAD/CAM systems, information entered through keyboards shouldbe displayed back to the user on a screen for verification.

### III. Digitizing Tablets

- A digitizing tablet is considered to be a locating as well as pointing device. It is a small, low-resolution digitizing board often used in conjunction with a graphics display.

- The tablet is a flat surface over which a stylus can be moved by the user.
- A tablet‘s typical resolution is 200 dots per inch
- The tablet operation is based on sensitizing its surface area to be able to track the pointing element motion on the surface.
- Several sensing methods and technologies are used in tablets. The most common sensing technology is electromagnetic, where the pointing element generates an out of phase magnetic field sensed by wire grid in tablet surface.

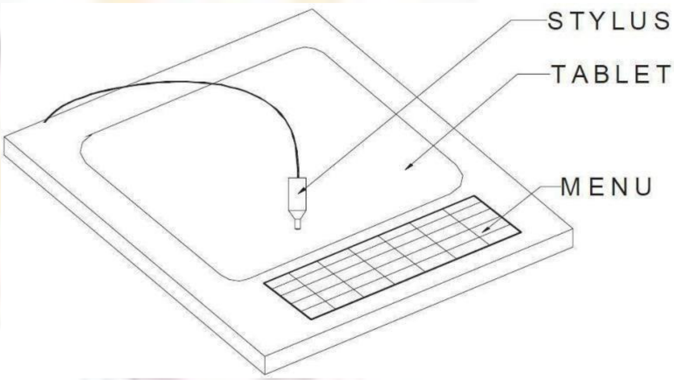



*Fig. 1.8 Digitizer*

## IV. Mouse

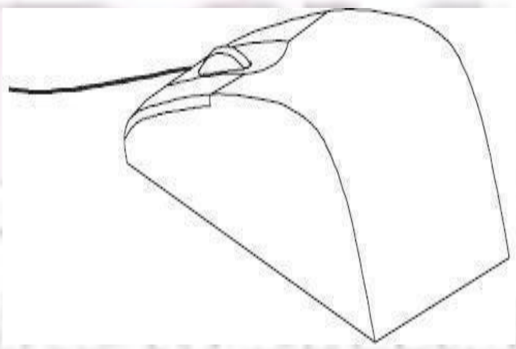


*Fig. 1.9 Mouse*

- • There are two basic types of mouse available mechanical and optical.
- The mechanical mouse has roller in order to record the mouse

motionin X and Y directions.

- In optical mouse, movements over the surface are measured by a lightbeam modulation technique.
- The light source is located at the bottom and the mouse must be in contact with the surface for screen cursor to follow its movement.

### V. Joy sticks & Trackballs

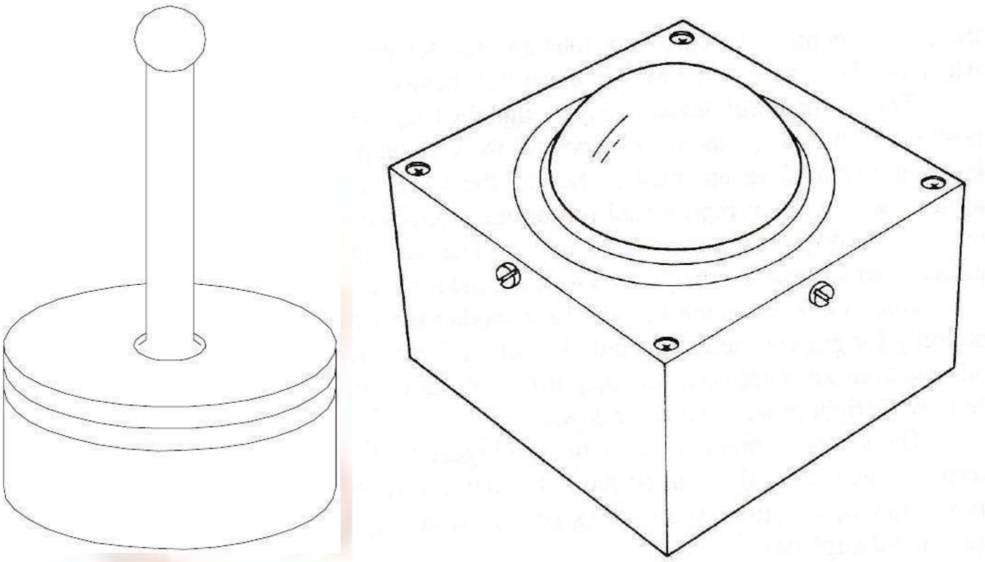


*Fig. 1.10 Joy stick & Track ball*

- The joystick works by pushing its stick backwards or forward or to left or right. The extreme positions of these directions correspond to the four corners of the screen.
- A trackball is similar in principal to a joystick but allows more precise fingertip control. The ball rotates freely within its mount.
- Both the joystick and trackball are used to navigate the screen display cursor. The user of a trackball can learn quickly how to adjust to any nonlinearity in its performance.

## CLASSIFICATIONOFHARDWARECONFIGURATIONS

The classification hardware configuration is as follows:

(a) Mainframe-based systems

(b) Minicomputer-based systems

(c) Microcomputer-based systems

(d) Workstation-based systems

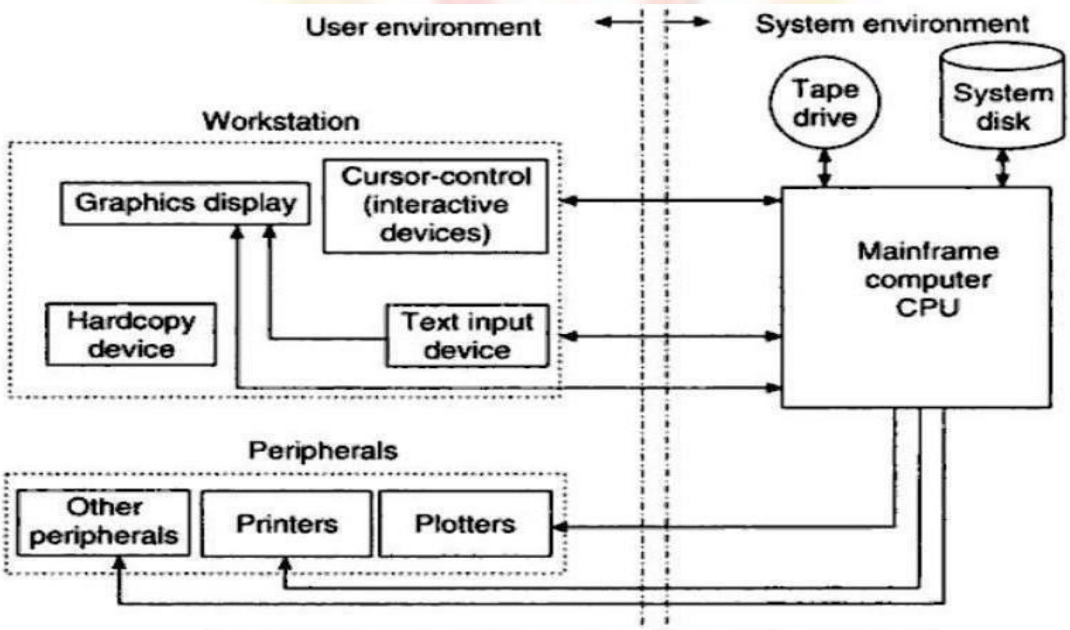
## Mainframe-based Systems

Mainframe-based CAD/CAM systems are used in large organizations for handling massive amounts of data and a multitude of concurrent activities of remote separate software applications. Mainframes often host hundreds of remote workstations operating and communicating over a vast network (sometimes covering thousands of kilometers and crossing international boundaries).

Below Figure shows a schematic of the mainframe-based CAD system components and details of a workstation. The computer environment is divided into:

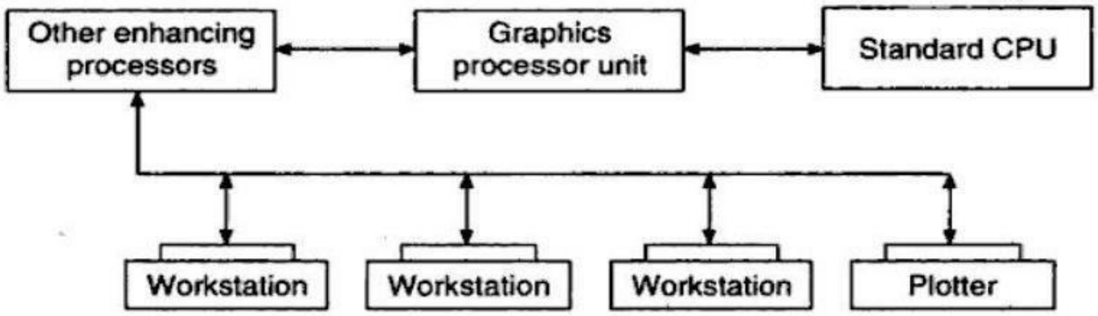
- The user environment
- The system environment

The user environment signifies the components and the area which the user can access. These components include primarily workstations and peripherals. The mainframe can support as many workstations as possible to avoid degradation of the response time between the users and the system. A typical workstation consists of input and output devices. The input devices may include cursor control devices for graphics input and text input devices. The cursor can be controlled via a light pen, joystick, mouse, electronic pen with a digital tablet, thumbwheel, or trackball. Text input can be input through a keyboard, which may have programmed function keys. Output devices consist of a graphics display with a hardcopy printer to provide convenient raster plots of full screen contents.



## Minicomputer-basedSystems

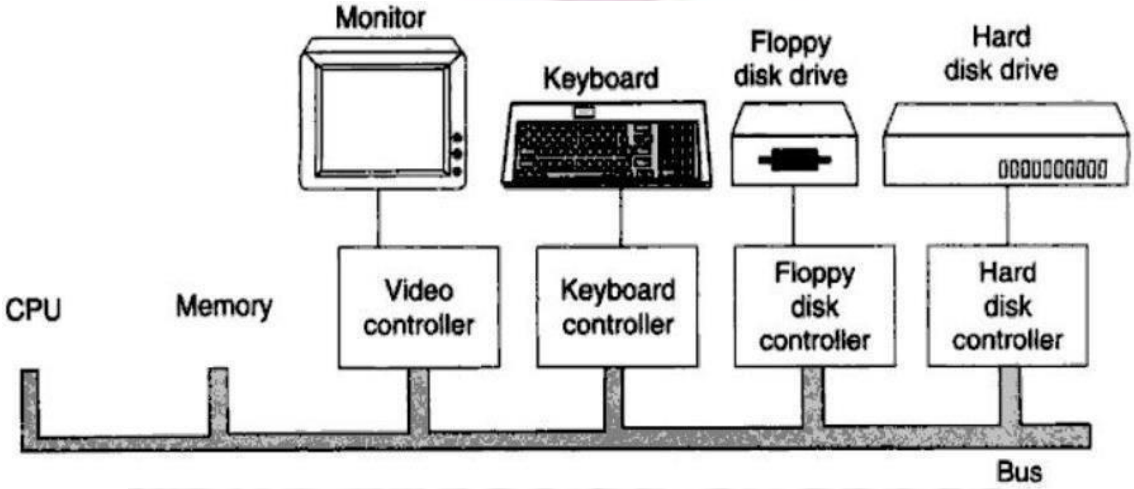
The development of VLSI (very large scale integrated) circuits has changed the basic principles of computer architecture and has directly led to the proliferation of minicomputers. Early versions on minis were 16-bit word, slow and limited-storage computers.




The DEC (Digital Equipment Corporation) PDP series offers a typical example. In the late 1970s, the arrival of super 32-bit word and virtual memory operating systems, boosted CAD/CAM applications and facilitated decentralization from mainframes. Minicomputers have enabled the rapid growth of the CAD/CAM industry. The 32-bit minicomputer is capable of handling complex geometric software and large quantities of data. The schematic of minicomputer is shown in above figure.

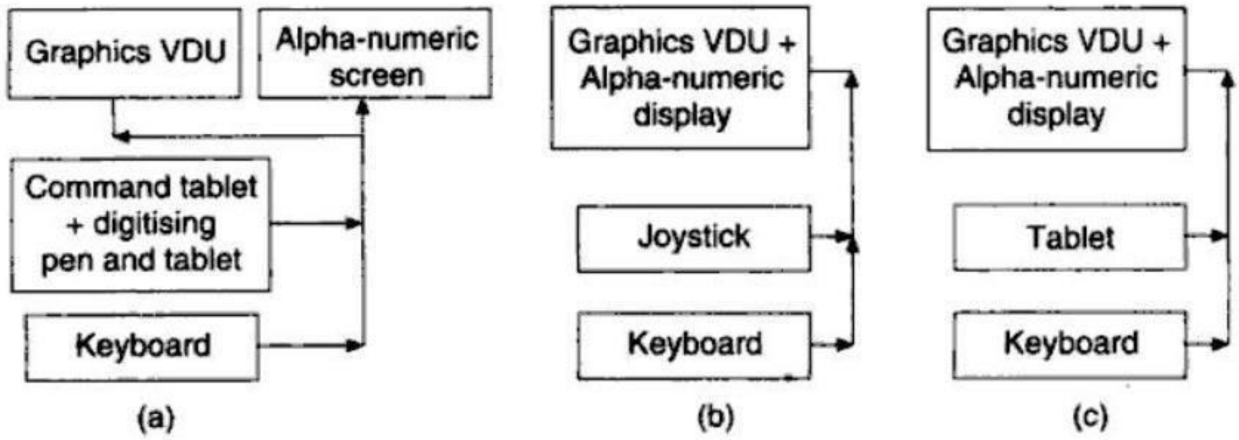
## Microcomputer-basedSystems

The advent of the IBM Personal Computer (PC) provided the first significant impetus for CAD on micros. Two main factors are responsible for the popularity and fast emergence of micro-based CAD systems. First, the speed, size, and accuracy problems are being reduced. Microcomputers of a 32-bit word length are available with enough memory size, disk storage, and speed for CAD/CAM applications. Second, various application programs have matured and cover most, if not all user needs.



## Workstation-based Systems

Graphics terminals attached to mainframes, minis, or PCs do not qualify as workstations. These terminals may be referred to as work stations* (two words). A workstation can be defined as a 'work station' with its own computing power to support major software packages, multitasking capabilities demanded by increased usage and complex tasks, and networking potential with other computing environments. The workstation concept seems to form (he basis of the present generation of CAD/CAM systems.




The basic elements of a CAD workstation are:

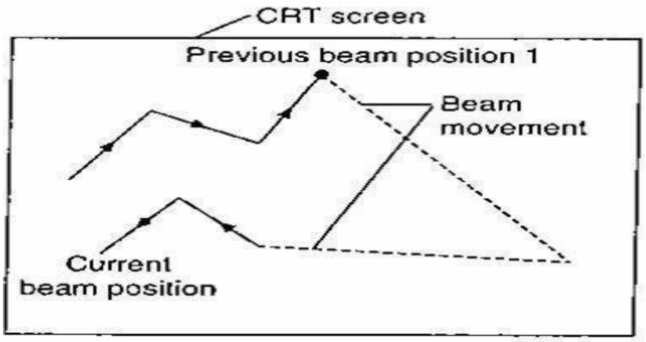
- A graphics screen called the VISUAL DISPLAY UNIT (VDU)
- An ALPHA-NUMERIC DISPLAY (word and number screen)
- A workstation PROCESSOR
- An electronic COMMAND TABLET
- A MENU facility
- A CURSOR CONTROL device
- A KEYBOARD
- A PRINTER/PLOTTER device

## GRAPHICAL DISPLAYS

The graphical display enables the user to view images and to communicate with the displayed images by adding, deleting, blanking and moving graphics entities on the display screen. Various display technologies are now available based on the concept of converting the computer electrical signals into visible images at high speed. The graphics display can be divided into two types based on the scan technology used to control the electron beam when generating graphics on the screen. These are:

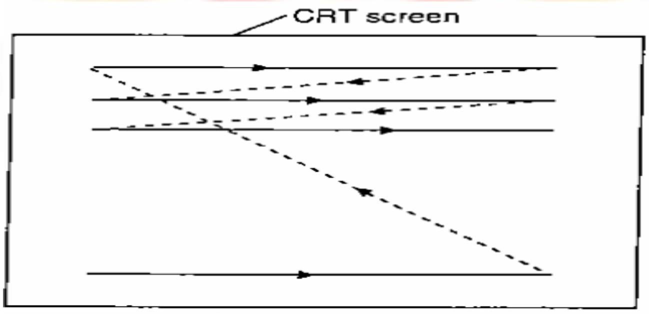
- Random scan
- Raster scan

In random scan, graphics can be generated by drawing vectors or line segments on the screen in a random order, which is controlled, by the user input and the software. The principle of random scan is illustrated in below figure.




Random scan

In raster scan, the screen is canned from left to right, top to bottom, all the time to generate graphics. The principle of random scan is illustrated in below figure.

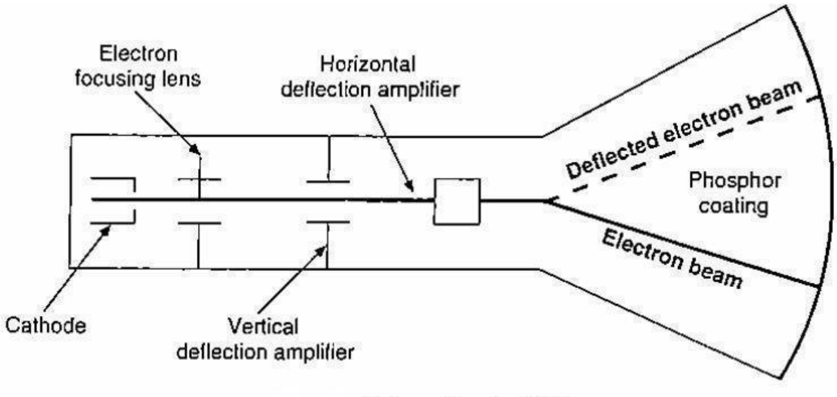



Raster scan

The graphic display technologies include:

- CRT (cathode ray tube)
- Liquid crystal display
- Plasma panel display

The CRT is basically an evacuated glass tube in which a beam of electrons is fired from an electron gun onto a phosphor-coated screen, resulting in an illuminated trace beingdisplayed on the screen.

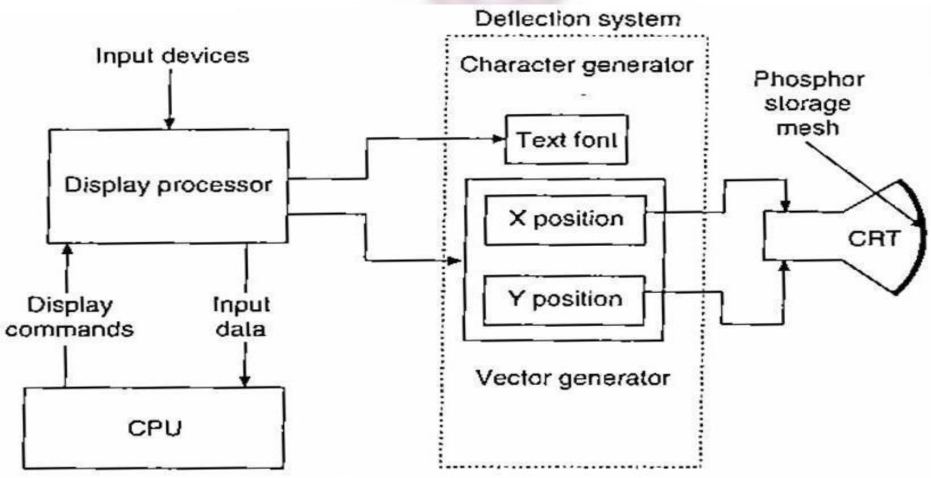



Schematic of a CRT..

Various types of CRT displays are broadly categorized into:

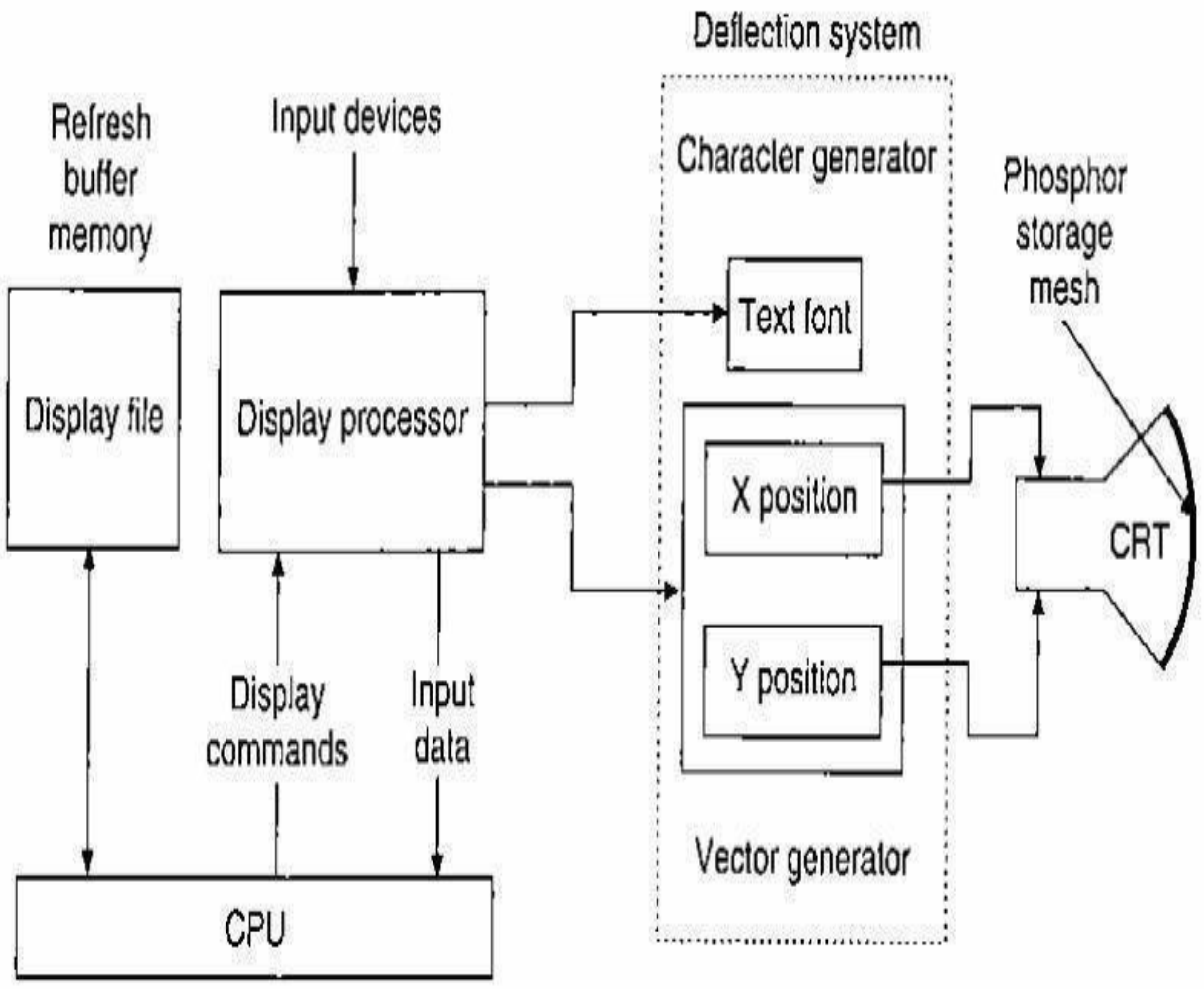
- Direct view storage tube (DVST)
- Vector refresh
- Raster refresh

The **DVST** (Direct View Storage Tube) has the standard CRT electron gun and deflection system for location of the beam onto the screen. The picture is stored as a charge in the phosphor mesh located behind the screen surface. Once displayed, the picture remains on the screen until it is explicitly erased. Therefore, complex pictures can be drawn without flicker at high resolution. One cannot alter a DVST picture except by erasing the entire screen and drawing it again. The inability to erase and edit individual areas of the drawing is a major drawback of the DVST system. Colored pictures are not usually available with a DVST. This can be a distinct disadvantage, particularly for three-dimensional drawings. Animation is also difficult to achieve, a factor that effectively disallows such vital facilities as tool-path simulation, and dynamic analysis of mechanisms.




Direct view storage tube.

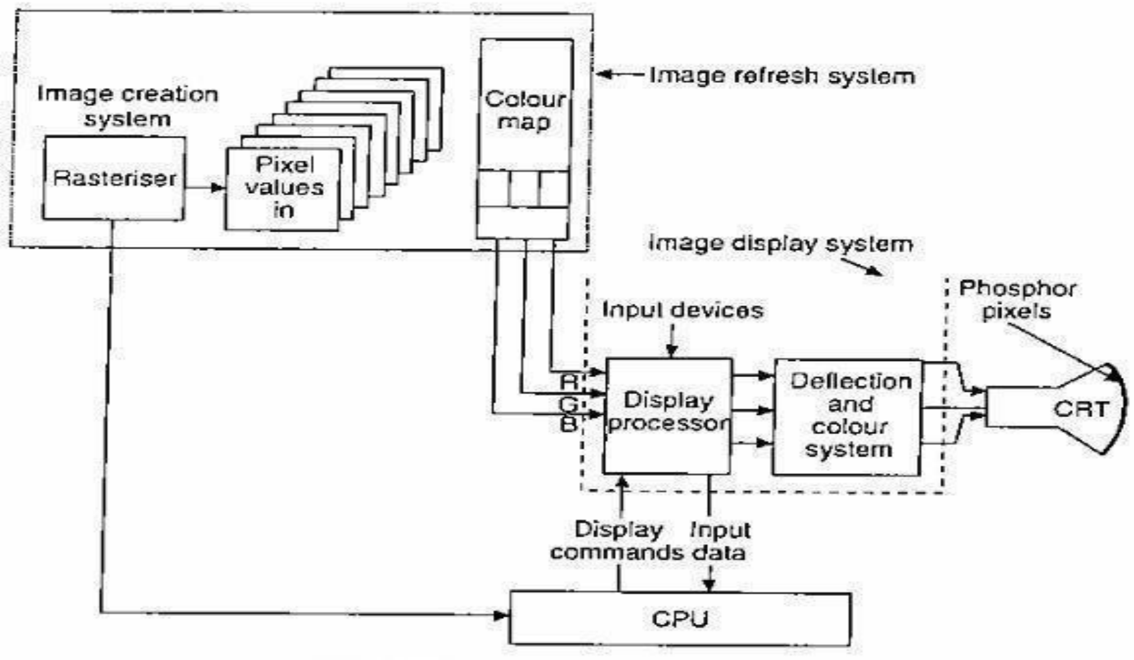
In **vector refresh display,** the deflection system of the CRT is controlled and driven by the vector and character generators and digital-to-analog converters. The refresh buffer stores the display file that contains points, lines, characters, and other attributes of the picture to be drawn. These commands are interpreted and processed by the display processor. The electron beam accordingly excites the phosphor that glows for a short period. In order to maintain a steady flicker-free image, the screen must be refreshed or re-drawn at least 30 or 60 times per second. Vector refresh displays are particularly noted for their bright, clear image, and high drawing speed. The refresh operation is well-suited to fast moving animation of the screen display in either 2D or 3D. The chief disadvantages of vector refresh displays are their high cost, and their tendency to flicker on complex drawings if the refresh rate becomes less than the flicker threshold of the eye. Color displays are possible, but again are only available at high cost.




Vector refresh display.

**Raster refresh display** works on the principle of a domestic television set. In raster display, the display screen area is divided horizontally and vertically into a matrix of small elements called picture elements (pixels). A pixel is the smallest addressable area on a screen as shown in Figure 2.25. A n N x M resolution defines a screen with N rows and M columns. Each row defines a scan line. A typical resolution of a raster display is 1280 X 1204. The pixels are controlled by the electron beam as it sweeps across the screen from one side to the other. The beam always starts its sweep from the top left-hand corner of the screen, regardless of what has been drawn, finishes on a horizontal line to the right, moves down one row of pixels, returns, and starts again from the left. The display is completed when the beam has reached the bottom right of the screen. It then refreshes by commencing the whole procedure again at the top left. Each refresh operation takes about 0.02 seconds. Images are displayed by converting geometric in format ion into pixel values, which arc then converted into electron beam deflection through the display processor and the deflection system.

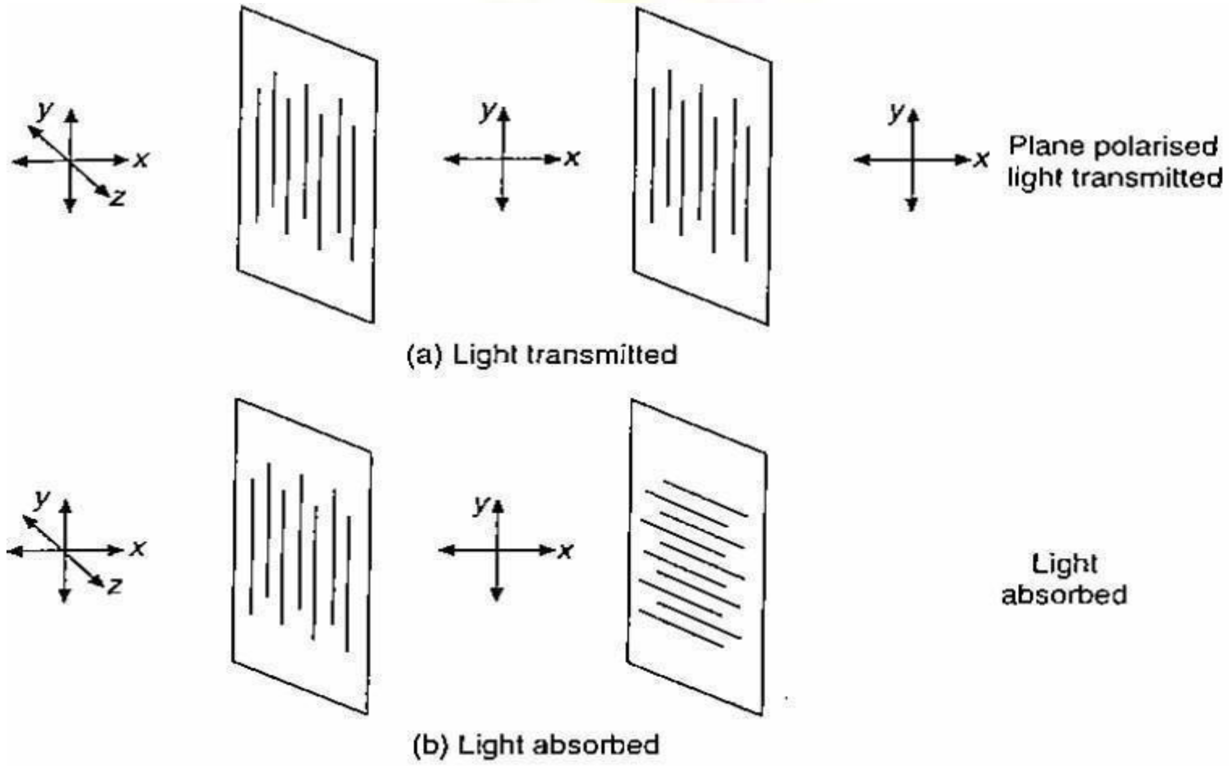
In a **color raster display**, there are three electron guns, one for each of the primary colors, red, green and blue. The electron guns are frequently arranged in a triangular pattern corresponding to a similar triangular pattern of red, green and blue phosphor dots on the face of the CRT. In order to ensure that the individual electron guns excite the correct phosphor dots (e.g., the red gun excites only the red phosphor dot), a perforated metal grid is placed between the electron guns and the face of the CRT. The perforations in the shadow mask are arranged in the same triangular pattern as the phosphor dots.




Colour raster refresh display

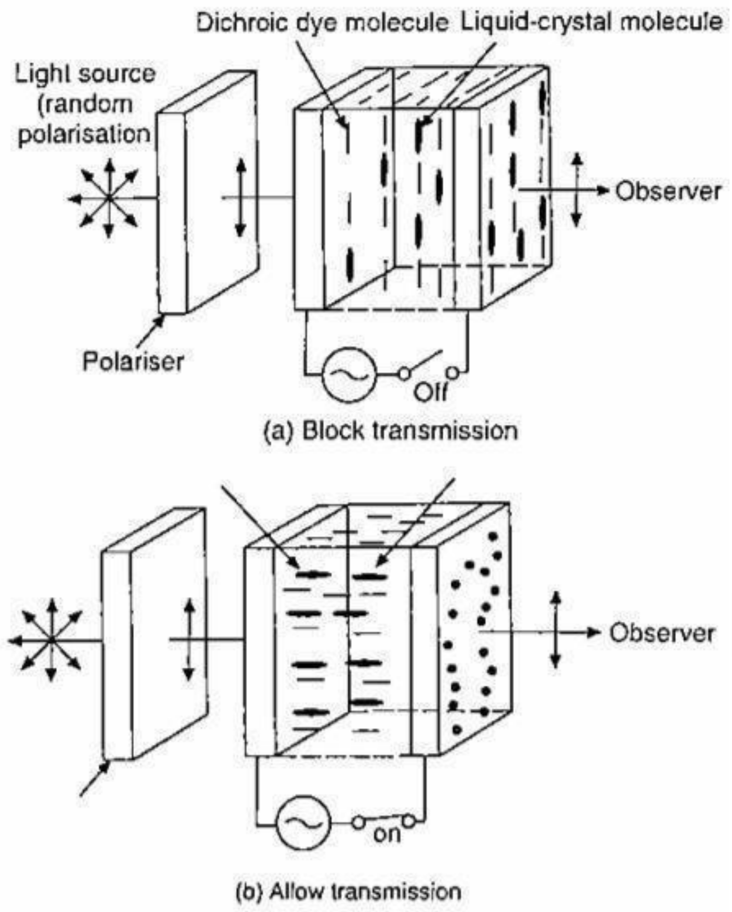
The distance between perforations is called the pitch. The color guns are arranged so that the individual beams converge and intersect at the shadow mask. Upon passing through [he hole in the shadow mask, the red beam, for example, is prevented or masked from intersecting either the green or blue phosphor dot; it can only intersect the red phosphor dot. By varying the strength of the electron beam for each individual primary color, different shades (intensities) are obtained. These primary color shades are combined into a number of colors for each pixel.

In a **liquid crystal display** transmitted or blocked, depending upon the orientation of molecules in the liquid crystal. The polarizing characteristics of certain organic compounds are used to modify the characteristics of the incident light. The basic principles of polarized light are shown in below figure. In figure (a) non-coherent light is passed through the first (left) polarizer. The resulting transmitted light is polarized in the *x-y* plane. Since the polarizing axis of the second polarizer is also aligned with the *x-y* plane, the light continues through the second polarizer. In figure (b) the polarizing axis of the second polarizer is rotated 90° to that of first. Consequently, the plane polarized light that passed through the first polarizer is absorbed by the second.




Polarisation of light.

Color liquid crystal displays use colored filters or phosphors with twisted nematic technology or use guest-host (dye) technology. Guest-host liquid crystal displays combine dichromic-dye guest molecules with the host liquid crystal molecules. The spectral characteristics of different guest molecules are used to produce different colors. The application of an electric field realigns the orientation of both the guest and host molecules, loallow transmission of light. A typical guest-host transmissive liquid crystal display is shownin below figure.



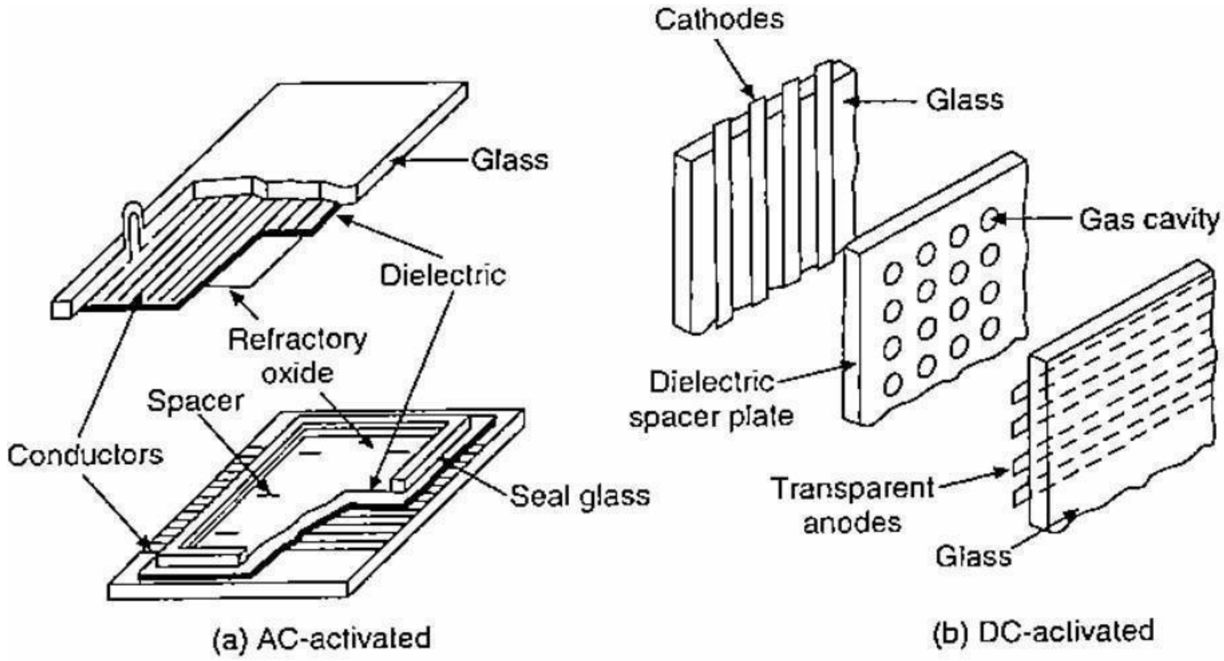

Guest-host liquid crystal display.

The plasma display contains a gas at low pressure sandwiched between horizontal and vertical grids of fine wires. A tower voltage will not start aglow but will maintain a glow once it is started. Normally, the wires have this low voltage between them. To see a pixel, the voltage is increased momentarily on the wires that intersect the desired point. To extinguish a pixel, the voltage on the corresponding wires is reduced until the glow cannot be maintained.

Plasma displays can be AC or DC or hybrid AC/DC activated. AC and DC plasma displays are shown in below Figure. The DC-activated display consists of a dielectric spacer plate, which contains the gas cavities sandwiched between plates containing the row-column conductors. The electric field is applied directly to the gas. A DC-activated plasma display requires continuous refreshing.

In the AC-activated plasma display, a dielectric layer is placed between the conductors and the gas. Thus, the only coupling between the gas and the conductors is capacitive. Hence, an AC-voltage is required to dissociate the gas. AC-activated plasma displays have bistable memory; thus, the necessity to continuously refresh the display is eliminated. Bistable memory is obtained by using a low AC voltage to keep alive voltage. The characteristic capacitive coupling provides enough voltage to maintain the activity in the conducting pixels, but not enough to activate non-conducting pixels.

A hybrid AC/DC plasma display uses DC voltage lo prime the gas and make it more easily activated by the AC voltage. The principal advantage of the hybrid AC/DC plasma display is reduced driver circuitry




Basic structure of gas discharge plasma displays.

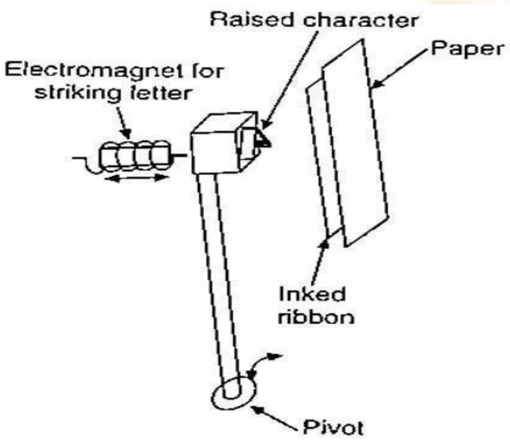
## HARDCOPY PRINTERS AND PLOTTERS

Printers and plotters are used to create check plots for offline editing and producing final drawings and documentation on paper. Printers usually provide hard copies of text as well as graphics.

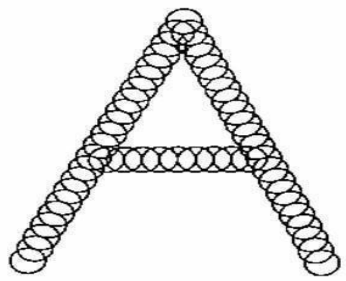
Printers are classified as follows on the basis of three principal technologies used for theiroperation:

- Impact dot matrix printer
- Ink jet printer
- Laser printer

**Impact dot matrix printer:** This is an electromechanical device, which creates images on paper from thousands of tiny dots when thin wires create an impact on an ink ribbon. The working principle of dot matrix printer is shown in Figure. Text characters and graphics elements are not displayed as separate items. The complete display is built up from reciprocating horizontal sweeps of the printing head as the paper winds around a rotating drum. Thus, the hard copy is constructed from dots in a similar manner to a raster screen display, with the resulting appearance being much the same. The resolutions that are available vary but range from 60 dots per inch lo 240 dots per inch. Their cost is comparatively low, but a major disadvantage is their noise because of the impact of the pins on the paper. For example, the letter ―A' is printed with 24 overlapping needles shown in Figure.



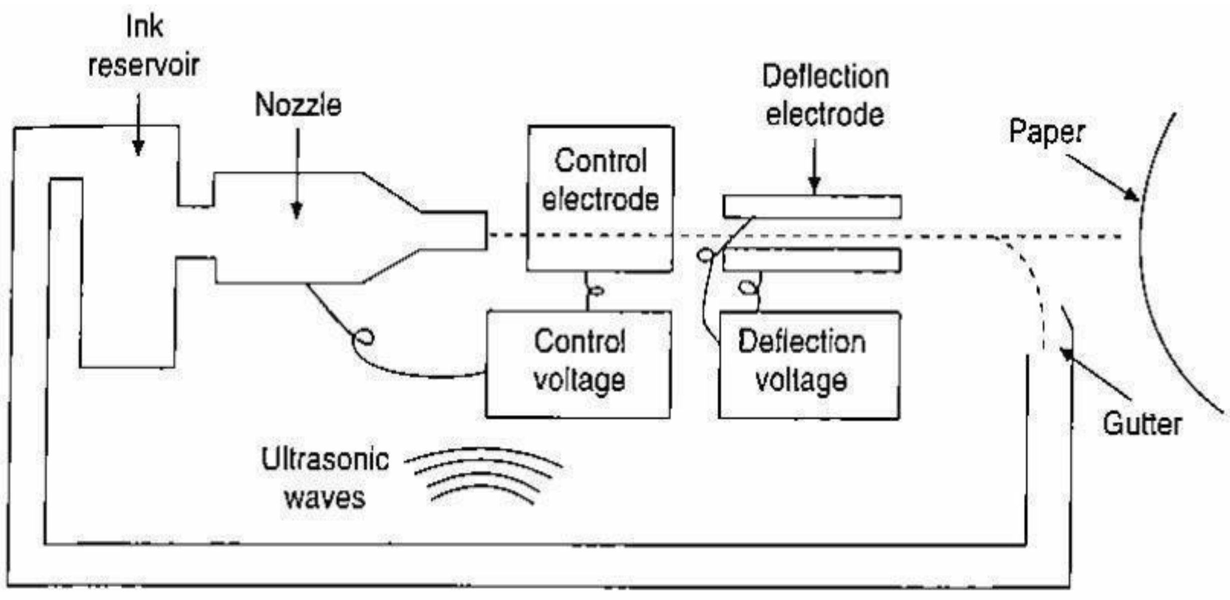

Impact dot matrix printer.



The letter 'A' printed with 24 overlapping needles.

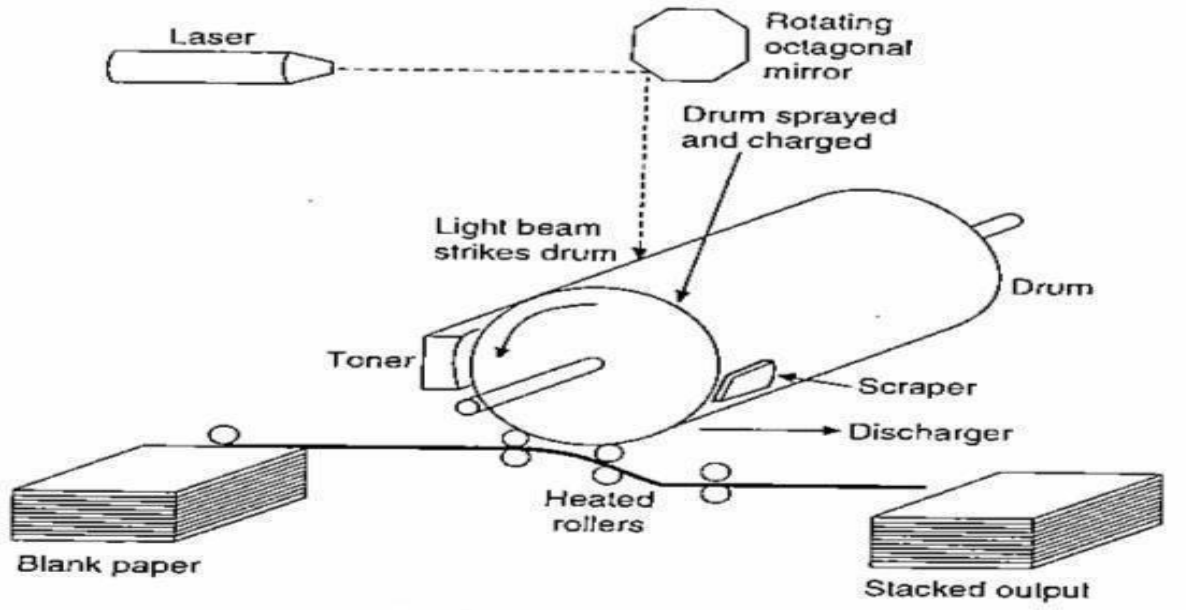
***Ink jet printer:*** This is a raster scan device. The basic principle is lo shoot tiny droplets of ink onto a medium. There are two types of ink jet printers, continuous flow and drop-on- demand. The continuous flow ink jet produces a stream of droplets by spraying ink out of the nozzle. The stream of ink from the nozzle is broken up into droplets by ultrasonic waves. If ink is desired on the medium, selected droplets are electrostatically charged. Deflection plates are then used to direct the droplet onto the medium. If not, the droplet is deflected into a gutter, from which the ink is returned to (he reservoir. Paper and transparency film are typical media. This system is shown in Figure.

A drop-on-demand printer fires ink at the medium only if a dot is required at a particular location. Here, ink from a reservoir is supplied to a nozzle under pressure. The ink is fired on demand by applying an electric voltage to a piezoelectric crystal as the head makes a pass across the medium. When a voltage is applied, the piezoelectric crystal expands, decreasing the volume of the ink chamber. These causes a drop of ink lo squirt out of the nozzle. Release of the voltage causes the piezoelectric crystal lo contract, decreasing the volume of the reservoir and sucking the link back onto the nozzle. The resolution of ink jet printers is determined by the size of the droplet and hence by the size of the nozzle. Because of the extremely small nozzle size required, nozzle clogging, ink contamination and air bubbles in the ink can be significant problems.




Continuous

***Laser printer:*** This is essentially an electrostatic plain paper copier with the difference that the drum surface is written by a laser beam. The working principle of a laser printer is illustrated in below figure.The heart of the printer is a rotating precision drum. At the start of each page cycle, it is charged up to about 1000 volts and coated with a photosensitive material. Then light from a laser is scanned along the length of the drum much like the electron beam in a CRT only instead of achieving the horizontal deflection using a voltage, a rotating octagonal mirror is used to scan the length of the drum. The light beam is modulated to produce a pattern of light and dark spots. The spots where the beam hits lose their electrical charge. After a line of dots has been painted, the drum rotates a fraction of a degree to allow the next line to be painted. Eventually, the first line of dots reaches the toner, a reservoir of an electroslatically sensitive black powder. The toner is attracted to those dots that are still charged, thus forming a visual image of that line. A little later in the transport path, the toner-coated drum is pressed against the paper, thus transferring the black powder to the paper. The paper is then passed through heated rollers to bind the toner to the paper permanently, fixing the image. Later in its rotation, the drum is discharged and scraped clean of any residual toner, preparing it for being charged and coated again for the next page.



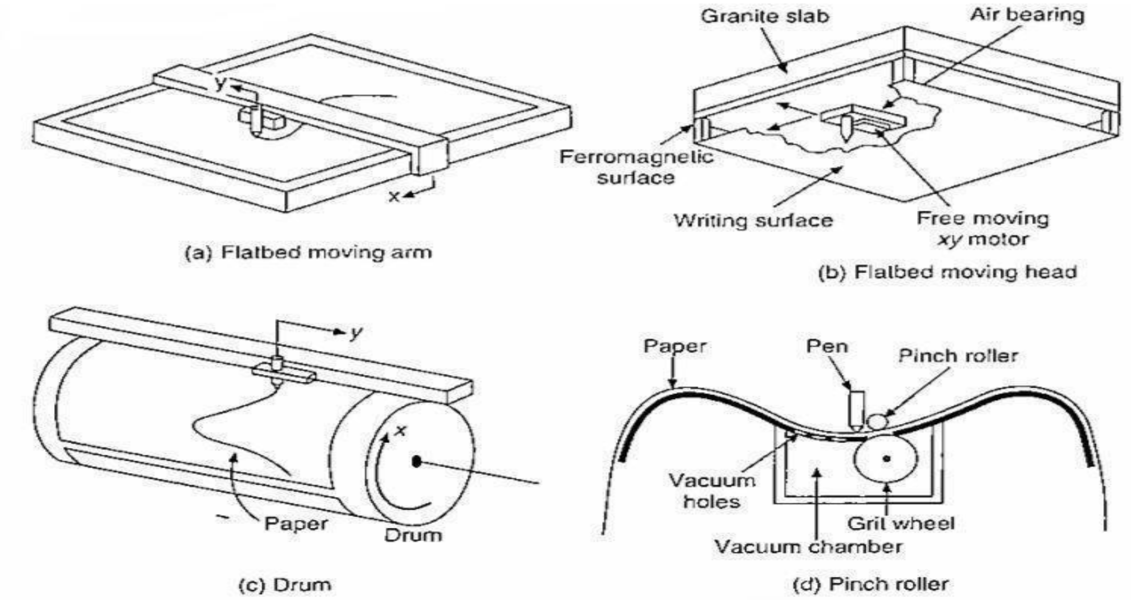

Operation of a laser printer.

***Plotter:*** This is a widely accepted output device for CAD/CAM applications. A large range (A0-A4) of plotters of varying sizes and prices are available. The accuracies achievable are very high and the plots can be made on all types of media such as paper, tracing paper and acetate film. There are three common types of conventional pen plotters: flatbed, drum and pinch roller. Pens may be-of wet ink, Ballpoint or felt-tip type. The basic mechanisms are shown in below Figure.

In a moving-arm flatbed plotter, the medium is fixed in position on the bed of the plotter. Two-dimensional motion of the plotting head is obtained by the movement of an arm suspended across the width of the plotter bed. This provides motion in one direction. Motion in the second direction is obtained by moving the plotting head along the suspended arm.

A moving head flatbed head plotter uses a plotting tool carriage suspended above the bed by magnetic forces that are counter-balanced by an air bearing. This arrangement provides nearly frictionless movement. Movement of the head in two dimensions is controlled electromagnetically by using the Sawyer motor principle.

In the drum plotter the paper is attached to a drum that rotates back and forth, thereby providing movement in one axis. The pen mechanism moves in the transverse direction to provide movement along the other axis.




schematic diagrams of pen and ink plotters

## ROLE OF COMPUTER IN MANUFACTURING

- Coordinate measuring machine (CMM)
- Rapid prototyping
- Standardization and Localization
- Conceptual modeling
- FMS (ASRS, AGV, CONVEYERS)
- CIM (Business data processing system)
- JIT, Kanban system
- Inspection
- Robots
- Machine vision
- Coefficient of thermal expansion
- Bill of material (MRP)
- PLM (product lifecycle management)
- Supply chain management
- Feed rotes, D.C, M/C speed
- Scheduling of parts
- Digital manufacturing