MODULE 1

1. APPLICATIONS OF COMPUTER GRAPHICS

Computer graphics is used in a lot of areas such as science, engineering, medicine, business, industry, government, art, entertainment, advertising, education and training. The different applications of computer graphics discussed below are

A. Computer aided design,
B. Presentation graphics,
C. Computer art,
D. Entertainment,
E. Education and training,
F. Visualization,
G. Image processing and,
H. Graphical user interfaces.

A. COMPUTER AIDED DESIGN

Computer graphics is used in the design of engineering and architectural systems such as buildings, automobiles, aircraft, watercraft, spacecraft, computers, textiles etc...

In the first stage of design, objects are displayed in wireframe format that shows the overall shape and internal details of the object as shown below.

(Fig: 1.1 - Computer Aided Design)

When object designs are complete, lighting and shading models are applied to produce displays the final product. Networks for communication and water supply can be designed using graphics packages.

The manufacturing process also can be computerized which will automate the construction of the product. Some mechanical parts are manufactured by describing how surfaces are formed with machine tools using CNC lathe machines.
B. PRESENTATION GRAPHICS

It is an area of computer graphics in which slides are designed to be used with projectors. It is used to summarize financial, statistical, mathematical, scientific and economic data for reports. The data can be represented in the form of bar charts and graphs.

![Presentation Graphics](Fig: 1.2 - Presentation Graphics)

C. COMPUTER ART

Computer graphics techniques are used in fine art and commercial art applications. Artists use a variety of techniques such as paint packages, special hardware, CAD packages and animation packages for designing objects. Some examples software’s are Paint and Photoshop.

Also artists can use a digitizer and stylus which can be used to paint pictures. An example picture generated using this way is shown below.

![Computer Art](Fig: 1.3 - Computer Art)

D. ENTERTAINMENT

Computer graphics methods are used in making motion pictures and television shows. For example movies such as Jurassic park. Music videos use graphics in several ways. Graphics objects can be combined with live action.
E. EDUCATION AND TRAINING

Computer generated models are used as financial aids. Virtual reality systems are used for training ship captains, aircraft pilots and heavy equipment operators. Flight simulators are used for training aircraft pilots.

F. VISUALIZATION

Scientists, engineers often need to analyze large amount of information to analyze certain processes. Satellite cameras collect thousands and even millions of images faster than they can be interpreted by human beings. But if these data are converted to visual form, trends can be analyzed. This is referred to as visualization.
Mathematicians, scientists use graphical representations of mathematical functions or processes.

G. IMAGE PROCESSING

Image processing apply techniques to modify or interpret existing pictures. Two applications of image processing are improving picture quality and machine perception of visual information. To apply image processing techniques, a photograph is digitized first using a scanner. Then digital methods are applied to rearrange picture parts, to enhance colors and improve the shading.

Medical applications widely use image processing techniques for surgery, tomography and for picture enhancements. Tomography is used to reconstruct cross sections from digital data. They are used to monitor internal functions and show cross sections during surgery.

Other image processing techniques in medical field are ultrasonic and nuclear medicine scanners. In ultrasonic, high frequency sound waves are used to generate digital data. Nuclear medicine scanners collect data from radiations. Image processing and computer graphics can be used in computer aided surgery. Cross sections of the body are obtained using imaging techniques.

H. GRAPHICAL USER INTERFACES

Nowadays all operating systems provide graphical interfaces. They contain a number of windows. User can interact with the computer system by making some clicks instead of typing commands.

(Fig: 1.7 - Graphical User Interfaces)

2. VIDEO DISPLAY DEVICES

Normally, the main output device in a graphics system is a video monitor. For e.g. a computer’s monitor.
The operation of most video monitors is based on the standard Cathode Ray Tube (CRT). Now several other technologies exist.

### 2.1 REFRESH CATHODE RAY TUBES

The following figure shows the basic operation of a CRT.

(Fig: 1.9 - Basic design of a magnetic-deflection CRT)

The electron gun emits a beam of electrons called cathode rays. This electron beam passes through the focusing and deflection systems. They direct the beam toward specified positions on the phosphor-coated screen. When the beam strikes a position on the screen, the phosphor emits a small spot of light at that position. Since the light emitted by phosphor disappears very rapidly, some method is needed for maintaining the screen picture. One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same positions. Such a type of display is called a refresh CRT.

The primary components of electron gun in a CRT are the heated metal cathode and a control grid.
A coil of wire called the filament is placed inside the cylindrical cathode structure. A current is passed through this coil of wire then heat will be produced. Then cathode will get this heat. This heat provided from the filament causes electrons to be boiled off the hot cathode surface. The inside of CRT envelope is vacuum. An accelerating anode is placed inside the CRT envelope. This free negatively charged electrons produced from the cathode are accelerated toward the phosphor coating by a high positive voltage generated from accelerating anode.

Control grid is used for controlling the intensity of this electron beam. Control grid is a metal cylinder that fits over the cathode. The intensity can be controlled by setting voltage levels on the control grid. It will stop the beam from passing through the small hole at the end of the control grid by repelling the electrons. Thus as the amount of –ve voltage applied to the control grid is increased the intensity of electron beam can be reduced. The amount of light emitted by the phosphor coating depends on the number of electrons striking the screen. The brightness of the display can be controlled by varying the voltage levels on the control grid.

The focusing system is placed in the CRT. Its function is to make the electron beam to converge into a small spot in the screen as it strikes the phosphor. Otherwise the electrons in the beam will repel each other and beam will spread out as it approaches the screen. Focusing can be done by either electric or magnetic field. Normally, in TV and computer monitors electrostatic focusing is commonly used. With electrostatic focusing electron beam passes through a positively changed metal cylinder. The action of focusing anode focuses the electron beam at the center of the screen.
The deflection of the electron beam is controlled by either magnetic or electric fields. CRT is now constructed with magnetic deflection coils mounted on the outside of the CRT envelope. Two pairs of coils are used. Coils in each pair are mounted on opposite sides of the neck of the CRT envelope. One pair is mounted on the top and bottom of the neck and the other pair is mounted on the opposite sides of the neck. The magnetic field produced by each pair of coils results in a transverse deflection force. Horizontal deflection is accomplished with one pair of coils and vertical deflection by the other pair. The proper deflection amounts are attained by adjusting the current through the coils.

Spots of light are produced on the screen by the transfer of the CRT beam energy to the phosphor. When the electrons in the beam collide with the phosphor coating, they are stopped and their kinetic energy is absorbed by the phosphor. Part of the beam energy is converted by friction into heat energy. The remaining beam energy causes electrons in the phosphor atoms to move up to higher quantum energy levels. After a short time, the excited phosphor electrons begin dropping back to their stable ground state, giving up their extra energy as small quantum’s of light energy. We are seeing the combined effect of all the electron light emissions. The frequency or the color of the light emitted by the phosphor is proportional to the energy difference b/w the excited quantum state and the ground state.

Different kinds of phosphors are available for use in a CRT. Besides color, a major difference between phosphors is their persistence. That is how long they will continue to emit light after the CRT beam is removed. Lower persistence phosphors require higher refresh rates to maintain a picture on the screen without flicker. Some phosphors have persistence greater than 1 second. Graphics monitors are usually constructed with persistence in the range from 10 to 60 microseconds.

The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution. Resolution is the number of points per centimeter that can be plotted horizontally and vertically. Thus two adjacent spots should appear distinct. As the number of electrons in the beam increases or the intensity of beam increases more electrons will strike a spot, the size of spot will increase. Thus resolution of a CRT is dependent on the type of phosphor, the intensity to be displayed and the focusing and deflection systems. Typical resolution in high quality systems is 1280 by 1024.

The physical size of a graphics monitor is given as the length of the screen diagonal with size varying from 12 inches to 27 inches or more.

Another property of video monitors is aspect ratio. This gives the ratio of vertical points to horizontal points necessary to produce equal length lines in both
directions on the screen. An aspect ratio of ¾ means that a vertical line plotted with 3 points has the same length as a horizontal line plotted with 4 points.

2.2 RASTER SCAN DISPLAYS

The most common type of display used in a graphics monitor that uses CRT is raster scan display. In a raster scan system the electron beam is swept across the screen one row at a time from the top to bottom. As the electron beam moves across each row the beam intensity is turned on and off to create a pattern of illuminated spots.

(Fig: 1.11 – Path of electron beam when using a raster scan technique)

Picture definition is stored in a memory area called refresh buffer or frame buffer. This memory area holds the set of intensity values for all the screen points. Stored intensity values are retrieved from the refresh buffer and pointed on the screen one row (scan line) at a time as in the above figure. Each screen point is referred to as a pixel. (Picture element)

(Fig: 1.12 – Refresh Buffer)

2.2.1 REFRESH BUFFER

Home television sets and printers are examples of systems that use raster scan methods.

Intensity range for pixel positions depends on the capability of the raster scan system. In a black and white system each point is either on or off. So only one bit per pixel is needed to control the intensity of screen positions as in the above fig that shows a refresh buffer that stores one bit per pixel.
When color and intensity variations are to be displayed, additional bits are needed. Up to 24 bits per pixel are included in higher quality systems. For e.g. A system with 24 bits per pixel and a screen resolution of 1024 by 1024 requires \((24/8 \times 1024\times1024)\) bytes i.e. 2 megabytes of storage for frame buffer. On a black and white system with one bit per pixel the frame buffer is called a bit map. For systems with multiple bits per pixel the frame buffer is referred to as a pixmap.

Refreshing on raster scan displays is done at the rate of 60 to 80 frames per second. Refresh rates are commonly described in units of cycles per second, Hertz where a cycle corresponds to one frame. Thus a refresh rate of 60 frames/sec means 60 Hz. At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line. The return to the left of side of the screen after refreshing each scan line is called the horizontal retrace of the electron beam. At the end of each frame (displayed \(1/80^{th}\) to \(1/60^{th}\) of a second) the electron beam returns (vertical retrace) to the top left corner of the screen to begin the next frame.

2.2.2 RASTER SCAN SYSTEMS

Interactive raster graphics systems employ several processing units. In addition to the CPU a special processor called video controller or display controller is used to control the operation of the display device. Organization of a simple raster scan system is shown below.

(Fig: 1.13 – Architecture of a simple raster graphics system)

The frame buffer or refresh buffer can be anywhere in the system memory. Video controller accesses the frame buffer to refresh the screen.

2.2.3 VIDEO CONTROLLER

The above fig shows a commonly used organization for rater scan systems. A fixed area of the system memory is reserved for the frame buffer. Video controller is given direct access to the frame buffer memory.
Frame buffer locations and screen positions are referenced in Cartesian coordinates (x, y). In some monitors, the coordinate origin is defined at the lower left screen corner.

(Fig: 1.14 – The origin of the coordinate system for identifying screen positions is usually specified in the lower-left corner)

(In many Personal computer systems, the coordinate origin is referenced a upper left corner of the screen.)

Scan lines are labeled from Ymax at the top of the screen to 0 at the bottom. Along each scan line screen pixel positions are labeled from 0 to Xmax. In the following figure, the basic refresh operations of the video controller are shown.

Two registers are used to store the coordinates of screen pixels. Initially x register is set to 0 and y register is set to Ymax. The value stored in the frame buffer for this pixel position is retrieved and used to set the intensity of the CRT beam. Then the x register is incremented by 1 and the process is repeated for the next pixel on the top scan line. After the last pixels on the top scan line have been processed, the x register is reset to 0 and y register is decremented by 1. Pixels along this scan line are then processed and the procedure is repeated for each successive scan line. After cycling through all pixels along the bottom scan line the video controller resets the registers to the first pixel position on the top scan line and the refresh process starts over.

Since screen must be refreshed at the rate of 60 frames per second, the above procedure will not work with typical RAM. This is because the cycle time is too slow. To speed up pixel processing video controller can retrieve multiple pixel values from the refresh buffer. These values are stored in a separate register and can be used to control the CRT beam intensity for a group of adjacent pixels. When that group of pixels has been processed, the next block of pixel values is retrieved from the frame buffer.
2.2.4 RASTER SCAN DISPLAY PROCESSOR

Fig shows a way to set up the organization of a raster system, which contains a separate display processor. This display processor is referred to as graphics controller or display coprocessor. The purpose of the display processor is to free the CPU from graphics chores. A separate display processor memory area can also be provided in addition to system memory.

The task of the display processor is to digitize a picture definition given in an application program into a set of pixel intensity values for storage in the frame buffer. This digitization process is called scan conversion. Graphics commands specifying straight lines and other geometric objects are scan converted into a set of discrete
intensity points. For e.g. Scan converting a straight-line segment means that we have to locate the pixel positions closest to the line path and store the intensity for each position in the frame buffer.

Display processors can perform a number of other operations such as generating various line styles, displaying color areas, and performing certain transformations and manipulations on displayed objects.

2.3 RANDOM SCAN DISPLAYS

When a display monitor that uses CRT is operated as a random scan display unit, the electron beam will be directed only to the parts of the screen where the picture is to be drawn. Random scan monitors draw a picture one line at a time and for this reason they are called vector displays or stroke writing or calligraphic displays. In this a picture will be interpreted as a number of lines.

The component lines of a picture are drawn as in the following fig.

(Fig: 1.17 – A random-scan system draws the component lines of an object in any order specified.)

Picture definition is stored as a set of line drawing commands in the memory called as display list or display program or refresh buffer. To display a specified picture, the system cycles through a set of commands in the display file, drawing each component line in turn. After all line drawing commands in the display file is processed the system cycles back to the first line command in the list.

Random scan displays are designed to draw all the component lines of a picture 30 to 60 times each second.

Random scan systems are designed for line drawing applications and cannot display realistic shaded scenes. Random scan systems produce smooth line drawings because the CRT beam directly follows the line path.
2.3.1 RANDOM SCAN SYSTEMS

The organization of a simple random scan system is shown below.

(Fig: 1.18 – Architecture of a simple random-scan system)

An application program is input and stored in the system memory along with a graphics package. Graphics commands in the application program are translated by the graphics package into a display file stored in the system memory. This display file is accessed by the display processor to refresh the screen. The display processor cycles through each command in the display file program once during every refresh cycle. Display processor in a random scan system is also called as a display processing unit or a graphics controller.

Graphics patterns are drawn on a random scan system by directing the electron beam along the component lines of the picture. Lines are defined by the values for their coordinate end points and these i/p coordinate values are converted to x and y deflection voltages. A scene is drawn one line at a time by positioning the beam to fill the line between specified end points.

2.4 COLOR CRT MONITORS

A CRT monitor displays color pictures by using a combination of phosphors that emit different coloured light. By combining the emitted light from the different phosphors a range of colors can be generated. Two methods for producing color displays with a CRT are the beam penetration method and shadow mask method.

The beam penetration method for displaying colour pictures has been used with random scan monitors. Two layers of phosphor usually red and green are coated on how far the electron beam penetrates into the phosphor layers. A beam of slow electrons excites only the outer red layer. A beam of very fast electrons penetrates through the red layer and excites the inner green layer. At intermediate speeds combinations of red and green light are emitted to show two additional colors, orange and yellow. The speed
of the electrons and hence the screen color at any point is controlled by the beam acceleration voltage. Beam penetration has been an inexpensive way to produce color in random scan monitors, but only 4 colors are possible. The quality of the picture is also not good.

Shadow mask methods are usually used in raster scan systems because they produce a much wide range of colors than the beam penetration method. A shadow mask CRT has 3 phosphor color dots at each pixel position. One phosphor dot emits red light another has 3 guns one for each color dot and a shadow mask grid just behind the phosphor coated screen.

Fig below shows the shadow mask used in color CRT systems.

(Fig: 1.19 – Operation of a delta-delta, shadow-mask CRT)

The 3 electron beams are deflected and focused as a group on to the shadow mask. Shadow mask contains a series of holes aligned with the phosphor dot patterns. When the 3 beams pass through a hole in the shadow mask they activate a dot triangle that appears as a small color spot on the screen. The phosphor dots in the triangles are arranged so that each electron beam can activate only its corresponding colour dot when it passes through the shadow mask.

We obtain colour variations in a shadow mask CRT by varying the intensity levels of the 3 electron beams. By turning off the red and green guns we get only the colour coming from the blue phosphor. Other combinations of beam intensities produce a small light spot for each pixel position, since our eyes tend to merge the 3 colours into one composite. The colour we see depend on the amount of excitation of the red, green and blue phosphors. A white area is the result of activating all the 3 dots with equal intensity. Yellow is produced with the green and red dots only. Magenta is produced
with the blue and red dots. Also, by setting intensity levels of the electron beams, several million colors can be generated.

Color CRTs in graphics systems are designed as RGB monitors. These monitors use shadow mask methods and take the intensity level for each electron gun (red, green, blue) directly from the computer system without any immediate processing. High quality raster systems have 24 bits per pixel in the frame buffer, allowing 256 voltage settings for each electron gun and nearly 17 million color choices for a pixel. An RGB color system with 24 bits of storage per pixel is generally referred to as a full color system or a true color system.

2.5 DIRECT VIEW STORAGE TUBES (DVST)

Another method for maintaining a screen image is to store the picture information inside the CRT instead of refreshing the screen. A direct view storage tube stores the picture information as a charge distribution just behind the phosphor coated screen. Two electron guns are used in a DVST. One called the primary gun is used to store the picture pattern. The second, the flood gun, maintains the picture display.

(Fig: 1.20 – Operation of Direct View Storage Tubes (DVST))

A DVST monitor has both advantages and disadvantages. Because no refreshing is needed, very complex pictures can be displayed at very high resolutions without flicker. Disadvantages of DVST systems are that they ordinarily do not display color and that selected parts of a picture cannot be erased. To eliminate a picture
section, the entire screen must be erased and the modified picture redrawn. The erasing and redrawing process can take several seconds for a complex picture.

2.6 FLAT PANEL DISPLAYS

Liquid Crystal displays (LCD), Plasma Panel, and Thin film electroluminescent displays are examples of flat panel displays. They are thin, have less weight, can be hanged on walls and they consume less power compared to CRT monitors.

They are classified into

Emissive displays and

Non- emissive displays.

Emissive displays convert electric energy into light. E.g. Plasma panel, thin film electroluminescent displays.

Non emissive displays convert sunlight or light from some other source into graphics patterns. E.g. LCD displays.

2.7 PLASMA PANEL

Plasma panel consists of two glass plates. Neon gas is filled in between the glass plates. A set of horizontal conducting electrodes are attached to one glass plate. A set of vertical conducting electrodes are attached to the other glass plate.

(Fig: 1.21 – Basic design of a plasma-panel display device)

The intersection of horizontal and vertical conductors defines a pixel position. When electricity (firing voltages) is applied to pair of horizontal and vertical conductors, the gas between that pixel positions will glow. Thus the plasma panel is an array of tiny neon bulbs.
2.8 THIN FILM ELECTROLUMINESCENT DISPLAYS

Electroluminescent displays have the same grid structure as in the plasma panel discussed above. But in this, the space between the glass plates is filled with a layer of electroluminescent material, such as zinc sulphide doped with manganese instead of neon gas. This will emit light when in an electric field (100,000V).

2.9 LIQUID CRYSTAL DISPLAYS

Nowadays, LCD display screens are becoming dominant. They started replacing traditional CRT monitors. LCD displays contain liquid crystal material. These liquid crystal materials are made up of long crystalline molecules. The individual molecules are normally arranged in a spiral fashion such that the direction of polarization of polarized light passing through is rotated 90°.

A liquid crystal display is made up of six layers as shown below. The front layer is a vertical polarizer plate. Next is a layer with thin grid wires. Next is a thin liquid crystal layer. Next is a horizontal grid wire next, then a horizontal polarizer, then a reflector.

Light entering through the front layer (vertical polarizer) is polarized vertically. As the light passes through the liquid crystal, the polarization is rotated 90° through the horizontal, so the light now passes through the rear polarizer (horizontal polarizer), is reflected from the reflective layer and returns through the 2 polarizers and crystal.
(Fig: 1.23 – Basic design of a liquid display display)

(Fig: 1.24 – Working of a liquid display display)
In the normal or in the ON state, this happens. When electricity is applied to liquid crystal materials, they all line up in the same direction, and thus will have no polarizing effect. In this, liquid crystals in the electric filled do not change the polarization of transmitted light, so the light remains vertically polarized and does not pass through the rear horizontal polarizer. The light is absorbed, so the viewer sees a dark spot on the display.

A pixel is defined by the intersection of horizontal and vertical grid wires.

(Fig: 1.25 – Layers of LCD Display)

3 INPUT DEVICES

In order to input data on graphics workstations, various devices are available. We know that most Computer systems have a keyboard and one or more additional devices for interactive input, some devices are mouse, trackball, space ball, joystick, digitizers, dials, button boxes, data gloves, touch panels, image scanners and voice systems.

3.1 KEYBOARD

Graphical system uses a keyboard to enter text strings. A keyboard is an efficient device for inputting data such as picture labels associated with a graphics display. In keyboards, cursor control keys and function keys are provided. Function keys allow users to enter commonly used operations in a single key stroke. Cursor control keys are used to select displayed objects or coordinate positions by positioning the cursor. Sometimes a trackball or space balls are included on the keyboard. A numeric keypad is often included on the keyboard for fast entry of numeric data.

3.2 MOUSE

Mouse is a small box used to position the screen cursor. At the bottom of mouse, wheels or rollers are provided which record the amount and direction of movement.
Instead of this an optical sensor can be used to detect mouse motion. For these the mouse is moved over a special mouse pad that has a grid of horizontal and vertical lines. The optical sensor detects movement across the lines in the grid.

The mouse is used for making relative changes in the position of screen cursor 1, 2 or 3 buttons are provided on the top of the mouse for signaling the execution of some operation.

Addition devices can be included in the basic mouse design. The Z mouse includes 3 buttons, a thumbwheel on the side, a trackball on the top and a standard mouse ball at the bottom. This design provides 6 degrees of freedom to select positions, rotations and other parameters. With a Z mouse we can pick up an object, rotate it, and move it in any direction. Z mouse is used in virtual reality, CAD and animation.

3.3 TRACKBALL AND SPACE BALL

Trackball is a ball that can be rotated with the palm of the hand to produce a screen cursor movement. Potentiometers attached to the ball measure the amount and direction of rotation. Trackballs are often mounted on keyboards or Z mouse. It is a 2 dimensional positioning device.

A space ball provides 6 degrees of freedom. Space ball does not actually move. Strain gauges measure the amount of pressure applied to the space ball to provide i/p for spatial positioning and orientation as the ball is pushed or pulled in various directions. Space balls are used in 3 dimensional positioning and selection operations.

(Fig: 1.26 – Trackball and Space Ball)

3.4 JOYSTICK

A joystick consists of a small, vertical lever mounted on base that is used to steer the screen cursor around. Joystick select screen positions with actual stick movement. Some joystick responds to pressure on the stick.

The distance that the stick is moved in any direction from its center position corresponds to screen cursor movement in that direction. Potentiometer mounted base of the joystick measure the amount of movement and springs return the stick to the center position when it is released.
In one type of joystick, the stick is used to activate switches that cause the screen cursor to move at a constant rate in the direction selected.

(Fig: 1.27 – Joystick)

3.5 DATA GLOVE

Data glove can be used to grasp a virtual object. The glove is constructed with a series of sensors that detect hand and finger motions. Electromagnetic coupling between transmitting and receiving antennas is used to provide information about the position and orientation of hand. Input from the glove can be used to position or manipulate objects in a virtual scene. A 2 dimensional projection of the scene can be viewed on a video monitor.

(Fig: 1.28 – Data Glove)

3.6 DIGITIZERS

Digitizer is a device for drawing, painting or interactively selecting coordinate positions on an object. These are used to i/p coordinate values in either a 2d or a 3d space. Graphics tablet is a type of digitizer. It is used to i/p 2d coordinates by activating a hand cursor or stylus at selected positions on a flat surface. A hand cursor contains cross hairs for sighting positions. A stylus is a pencil shaped device that is pointed at positions on the tablet.

The artists digitizing system uses electromagnetic resonance to detect the 3d position of the stylus. This allows an artist to produce different brush strokes with
different pressures on the tablet surface. Graphics tablets provide a highly accurate method for selecting coordinate position.

Many graphics tablets are constructed with a rectangular grid of wires embedded in the tablet surface. Electromagnetic pulses are generated in sequence along the wires and an electric signal is induced in a wire coil in an actuated stylus or hand cursor to record a tablet position. Acoustic tablets use sound waves to detect a stylus position. Strip microphones or point microphones are used to detect the sound emitted by an electrical spark from a stylus tip. The position of the stylus is calculated by timing the arrival of the generated sounds at the different microphone position. An advantage of 2 dimensional acoustic tablets is that the microphones can be placed on any surface to form the tablet work area.

Three-dimensional digitizers use sonic or electromagnetic transmissions to record positions. A coupling between the transmitters and receiver is used to compute the location of a stylus as it means over the surface of an object. As the points are selected on a real world object, a wire frame outline of the surface is displayed on the computer Screen.

3.7 IMAGE SCANNERS

(Fig: 1.29 – Digitizers)

(Fig: 1.30 – Image Scanners)
If we have drawings, graphs recorded in a paper and also color and b/w photos or text, we can store these in a Computer for processing with an image scanner. Image scanner contains an optical scanning mechanism that moves over the information to be stored. The gradations of gray scale or color are then recorded and stored in an array. Once we have an internal representation of a picture, we can process that picture.

### 3.8 TOUCH PANELS

Touch panels allow displayed objects or screen positions to be selected with the touch of a finger. One application of touch panels is for the selection of processing options that are represented with graphical icons.

Touch input can be recorded using optical, electrical or acoustical methods.

Optical touch panels employ a line of infrared LEDs along one vertical edge and along one horizontal edge of the frame. The opposite vertical and horizontal edges contain light detectors. These detectors are used to record which beams are interrupted when the panel is touched. The 2 crossing beams that are interrupted identify the horizontal and vertical coordinates of the screen position selected.

An electrical touch panel is constructed with 2 transparent plates separated by a small distance, one of the plates is coated with a conducting material and the other plate is coated with a resistive material. When the outer plate is touched, it is forced into contact with the inner plate. This contact creates a voltage drop across the resistive plate that is converted to the coordinate values of the screen position.

![Touch Panel Image](image)

(Fig: 1.31 – Touch Panels)

In acoustical touch panels, high frequency sound waves are generated in the horizontal and vertical directions across a glass plate. Touching the screen causes part of the each wave to be reflected from the finger to the emitters. The screen position at
the point of contact is calculated from a measurement of time interval b/w the transmission of each wave and its reflection to the emitter.

3.9 LIGHT PENS

It is a pencil shaped device. It is used to select screen positions by detecting the light coming from points on the CRT screen. They are sensitive to the short burst of light emitted from the phosphor coating at the instant the electron beam strikes a particular point.

An activated light pen pointed at a spot on the screen as the electron beam lights up that spot, generates an electrical pulse that causes the coordinate position of the electron beam to be recorded. This recorded light pen coordinates can be used to position an object or to select a processing option.

(Fig: 1.32 – Light Pen)

3.10 VOICE SYSTEM

Speech recognizers are used in some graphics work stations as i/p devices to accept voice commands. The voice system i/p can be used to initiate graphics operations. These systems operate by matching an i/p against a predefined dictionary of words and phrases.

A dictionary is set up for a particular operator by having the operator speak the command word to be used into the system. Each word is spoken several times and the system analyses the word and form a frequency pattern for the word in the dictionary along with the function to be performed.

Later when a voice command is given, the system searches the dictionary for a match. Voice i/p is typically spoken into a microphone mounted on a handset.
3.11 HARDCOPY DEVICES

We can obtain hard copy o/p of images in several formats. For presentations, we need slides. We can send images to devices that will produce 35mm slides or overhead transparencies.

We can put our pictures on paper by directing graphics o/p to a printer or plotter. The quality of the pictures obtained from a device depends on dot size and the no of dots / inch that can be displayed.

Printers produce output by either impact or non-impact methods. Impact printer’s press formed character faces against an inked ribbon o to the paper. E.g. a line printer.

(Fig: 1.33 – Hardcopy Devices)

Non-impact printers and plotters use laser techniques, inkjet sprays, and xerographic processes to get images on to the paper. Character impact printers have a dot matrix print head containing a rectangular array of wire pins with the number of pins depend on the quality of printer. Individual character or graphics patterns are obtained by retracing certain pins so that the remaining pins form the pattern to be printed.

In a laser device a laser beam creates a charge distribution on a rotating drum coated with photoelectric material. Toner is applied to the drum and the transferred to the paper.

Inkjet methods produce output by squirting ink in horizontal rows across a roll of paper wrapped on a drum. The electrically charged ink stream is deflected by an electric field to produce dot matrix pattern.

An electrostatic device places a negative charge on the paper one complete row at a time along the length of the paper. Then the paper is exposed to a toner. The toner is positively charged and is attracted to negatively charged areas where it adheres to produce the specified output. Electro thermal methods use heat in a dot matrix print head to output patterns on heat sensitive paper.