

# UNIT – 1

## Introduction to Computer Graphics

### Unit-01/Lecture-01

#### Introduction

[RGPV/DEC-2011(10)]

Although computer graphics is a vast field that encompasses almost any graphical aspect, we are mainly interested in the generation of images of 3-dimensional scenes. Computer imagery has applications for film special effects, simulation and training, games, medical imagery, flying logos, etc.

Computer graphics relies on an internal model of the scene, that is, a mathematical representation suitable for graphical computations. The model describes the 3D shapes, layout and materials of the scene.

This 3D representation then has to be projected to compute a 2D image from a given viewpoint, this is the rendering step. Rendering involves projecting the objects (perspective), handling visibility (which parts of objects are hidden) and computing their appearance and lighting interactions. Finally, for animated sequence, the motion of objects has to be specified. We will not discuss animation in this document.

#### Pixels

A computer image is usually represented as a discrete grid of picture elements a.k.a. pixels. The number of pixels determines the resolution of the image. Typical resolutions range from 320\*200 to 2000\*1500. For a black and white image, a number describes the intensity of each pixel. It can be expressed between 0.0 (black) and 1.0 (white). However, for internal binary representation reasons, it is usually stored as an integer between 0 (black) and 255 (white).

Because the image is represented by a discrete array of pixels, aliasing problems may occur. The most classical form of aliasing is the jaggy aspect of lines (see figure below). Antialiasing techniques are thus required. In the case of the line, it consists in using intermediate gray levels to “smooth” the appearance of the line. Another form of aliasing can be observed on television when people wear shirts with a fine striped texture. A flickering pattern is observed because the size of the pattern is on the same order of magnitude as the pixel size.

#### A SURVEY OF COMPUTER GRAPHICS

Nowadays, Computer Graphics are used routinely in various areas as Science, Engineering, Medicine, Business, Industry, Government, Art, Entertainment, Advertising, Education and Training. Some of the Graphics applications are as follows:

#### Computer-Aided Design:

A major use of Computer Graphics is in Design Processes, particularly for engineering and architectural systems. CAD (Computer-Aided Design) methods are used in the design of buildings, automobiles, aircraft, watercraft, spacecraft, computers, textiles and many other products.

In this,

- Objects are first displayed in a Wireframe outline form that shows the overall shape and internal features of objects. It also allows the designers to quickly see the effects to interactive adjustment to design shapes.
- Software packages for CAD applications typically provide the designer with a multi-window environment.
- Animations are often used in CAD applications. Real-time animations using

wireframe displays on a video monitor are useful for testing performance of a vehicle or system.

When object designs are complete, or nearly complete, realistic lighting models and surface rendering are applied to produce displays that will show the appearance of the final product. Architects use interactive graphics methods to layout floor plans, such as positioning of rooms, doors, windows, stairs, shelves, counters and other building features, electrical outlets, etc. Realistic displays of architectural designs permit both architects and their clients to study the appearance of buildings. Many other kinds of systems and products are designed using either general CAD packages or specially developed CAD software.

#### **Presentation Graphics:**

- Presentation Graphics is used to produce illustrations for reports or to generate 35-mm slides or transparencies for use with projectors.
- It is commonly used to summarize financial, statistical, mathematical, scientific and economic data for research reports, managerial reports, consumer information bulletins and other types of reports.
- Typical examples of presentation graphics are bar charts, line graphs, surface graphs, pie charts and other displays showing relationships between multiple parameters.

#### **Computer Art:**

Computer Graphics methods are widely used in both fine art and commercial art applications. Artists use a variety of computer methods, including special-purpose hardware, artists' paint brush programs, other paint packages, specially developed software, symbolic mathematics packages, CAD packages, desktop publishing software and animation packages that provide facilities for designing object shapes and specifying object motions.

- The artist uses a combination of three-dimensional modelling packages, texture mapping, drawing programs and CAD software.
- There is a Pen Plotter with specially designed software that can create "automatic art" without intervention from the artist.
- Another art is "mathematical" art, in which the art is the uses a combination of mathematical functions, fractal procedures, mathematical software, ink-jet printers and other systems to create a variety of three-dimensional and two-dimensional shapes and stereoscopic image pairs.
- A common graphics method employed in many commercial is morphing, where one object is transformed into another. This method has been used in TV commercials such as logo design, advertising, etc.

#### **Entertainment:**

Computer Graphics methods are now commonly used in making motion pictures, music videos and television shows. Sometimes the graphics scenes are displayed by themselves and sometimes graphics objects are combined with the actors and live scenes.

Music Videos use graphics in several ways. Graphics objects can be combined with the live action, or graphics and image processing techniques can be used to produce morphing effects. Many TV series regularly employ Computer Graphics methods.

#### **Education and Training:**

Computer-generated models of physical, financial and economic systems are often used as educational aids. Models of physical systems, physiological systems, population trends or equipment such as the color-coded diagram can help trainers to understand the operation of the system.

For some training applications, special systems are designed. Examples of such specialized systems are the simulators for practice sessions or training of ship captains, aircraft pilots, heavy-equipment operators and air traffic-control personnel.

Some simulators have no video screens, but most simulators provide graphics screens for visual operation.

For example, in an automobile-driving simulator, it is used to investigate the behaviour of drivers in critical situations.

#### **Visualization:**

- Producing graphical representations for scientific, engineering and medical data sets and processes is generally referred to as Scientific Visualization. The term Business Visualization is used in connection with data sets related to commerce, industry and other non scientific areas.
- There are many different kinds of data sets and effective visualization schemes depend on the characteristics of the data. Color coding is one way to visualize a data set.
- Additional techniques include contour plots, graphs and charts, surface rendering and visualizations of volume interiors. In addition, Image Processing techniques are combined with Computer Graphics to produce many of the data visualization.

#### **Image Processing:**

Image Processing is a technique used to modify or interpret existing pictures, such as photographs and TV scans. Two principal applications of Image Processing are, improving picture quality machine perception of visual information as used in Robotics.

To apply image-processing methods, we first digitize a photograph or other picture into an image file. Then digital methods can be applied to rearrange picture parts, to enhance color separations, or to improve the quality of shading.

These techniques are used extensively in commercial art applications that invoke the retouching and rearranging the sections of photographs and other artwork. Similar methods are used to analyze satellite photos of the earth and photos of galaxies.

Image Processing and Computer Graphics are typically combined in many applications. For example, in Medical field this technique is used to model and study physical functions, to design artificial limbs and to plan and practice surgery. This application is generally referred as Computer-Aided Surgery.

#### **Graphical User Interfaces:**

Nowadays all the software packages provide a Graphical Interface. A major component of a graphical interface is a window manager that allows a user to display multiple-window areas. Each window can contain a different process that can contain graphical or non-graphical displays. Interfaces also display menus and icons for fast selection of processing operations and parameter values.

S.NO	RGPV QUESTIONS	Year	Marks
1.	What is computer graphics? Discuss about its application areas?	Dec, 2011	10

**Introduction to Raster scan displays**

**Introduction to Raster scan displays**

**[RGPV/JUNE-2012(10)]**

- It is common now for software packages to provide a graphical interface. A major component of a graphical interface is a window manager that allows a user.
- To display multiple-window areas. Each window can contain a different process that can contain graphical or non-graphical displays. To make a particular window active, we simply click in that window using an interactive pointing device.
- Interfaces also display menus and icons for fast selection of processing options or parameter values. An icon is a graphical symbol that is designed to look like the processing option it represents.
- The advantages of icons are that they take up less screen space than corresponding textual descriptions and they can be understood more quickly if well designed. Menus contain lists of textual descriptions and icons.
- A typical graphical interface, containing a window manager, menu displays, and icons. In this example, the menus allow selection of processing options, color values, and graphics parameters. The icons represent options for painting, drawing, zooming, typing text strings, and other operations connected with picture construction.

Eg: Acrobat Reader, photo shop etc.

**Graphical User Interfaces:**

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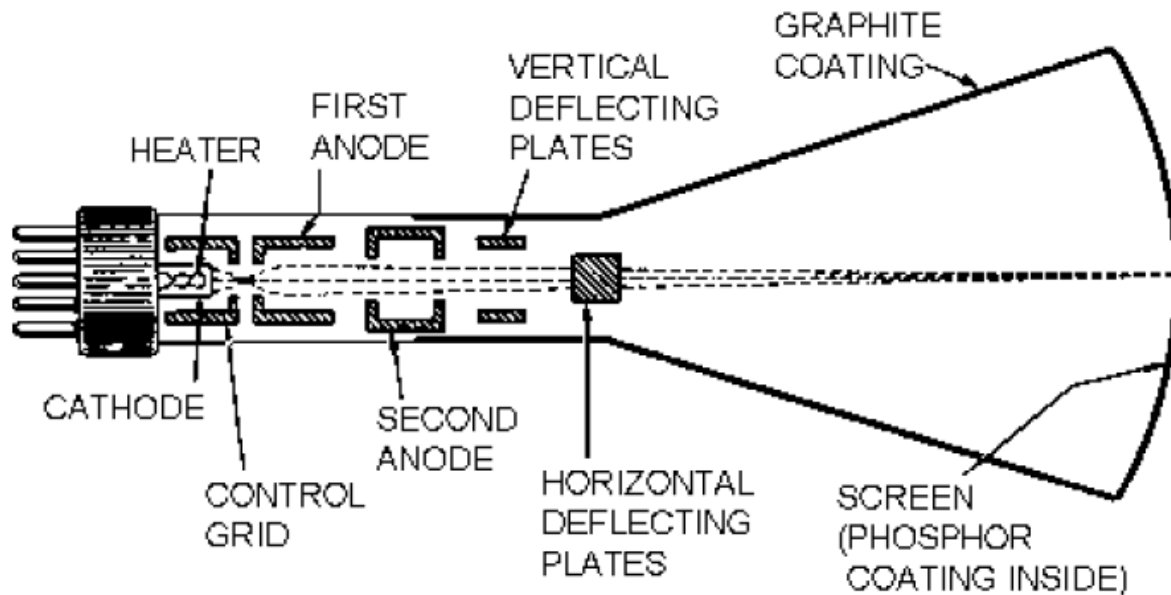
**OVERVIEW OF GRAPHICS SYSTEM : VIDEO DISPLAY DEVICES**

The primary output device in a graphics system is a Video Monitor. The functionality of most video monitors is based on the standard Cathode-Ray Tube (CRT) design.

**Refresh Cathode Ray Tubes:**

A beam of electrons (cathode rays) emitted by an electron gun, passes through focusing and deflection systems that direct the beam toward specified positions on the phosphor-coated screen. The phosphor then emits a small spot of light at each position contacted by the electron beam.

The phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same points.



- The primary components of an electron gun in a CRT are the heated metal cathode and a control grid. Heat is supplied to the cathode by directing a current through a coil of wire, called the filament, inside the cylindrical cathode structure.
- The focusing system in a CRT is needed to force the electron beam to converge into a small spot as it strikes the phosphor.
- As with focusing, deflection of the electron beam can be controlled either with electric fields or with magnetic fields. One pair of plates is mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control horizontal deflection.
- Different kinds of phosphor are available for use in a CRT. Besides, color a major difference between phosphor is either persistence, how long they continue to emit light after the CRT beam is removed.
- The maximum number of points that can be displayed without overlap on a CRT is referred to as the Resolution.
- Another property of video monitor is aspect ratio, which gives the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen.

### ***Raster-Scan Displays:***

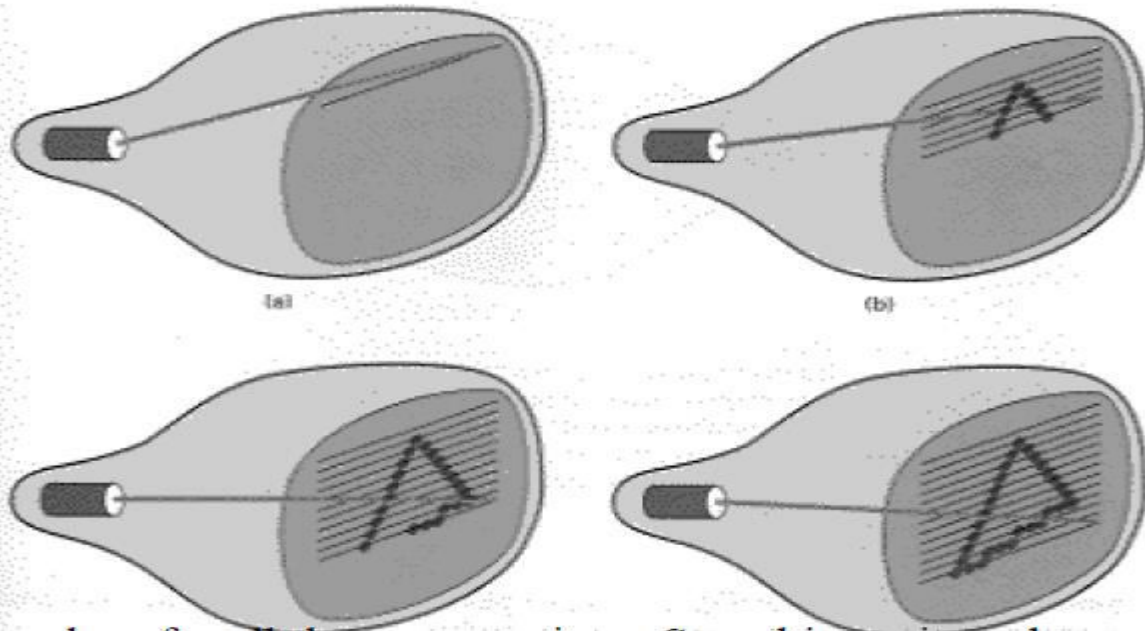
The most common type of graphics monitor employing a CRT is the Raster-Scan Display, based on television technology. In Raster-Scan systems, the electron beam is swept across the screen, one row at a time from top to bottom. As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots. Picture definition is stored in a memory area called the Refresh Buffer or Frame Buffer.

This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and “painted” on the screen one row (scan line) at a time. Each screen point is referred to as a Pixel or Pel (Picture Element).

On a Black-and-White system with one bit per pixel, the frame buffer is commonly called a Bitmap. For systems with multiple bits per pixel, the frame buffer is often referred to as a Pixmap.

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.

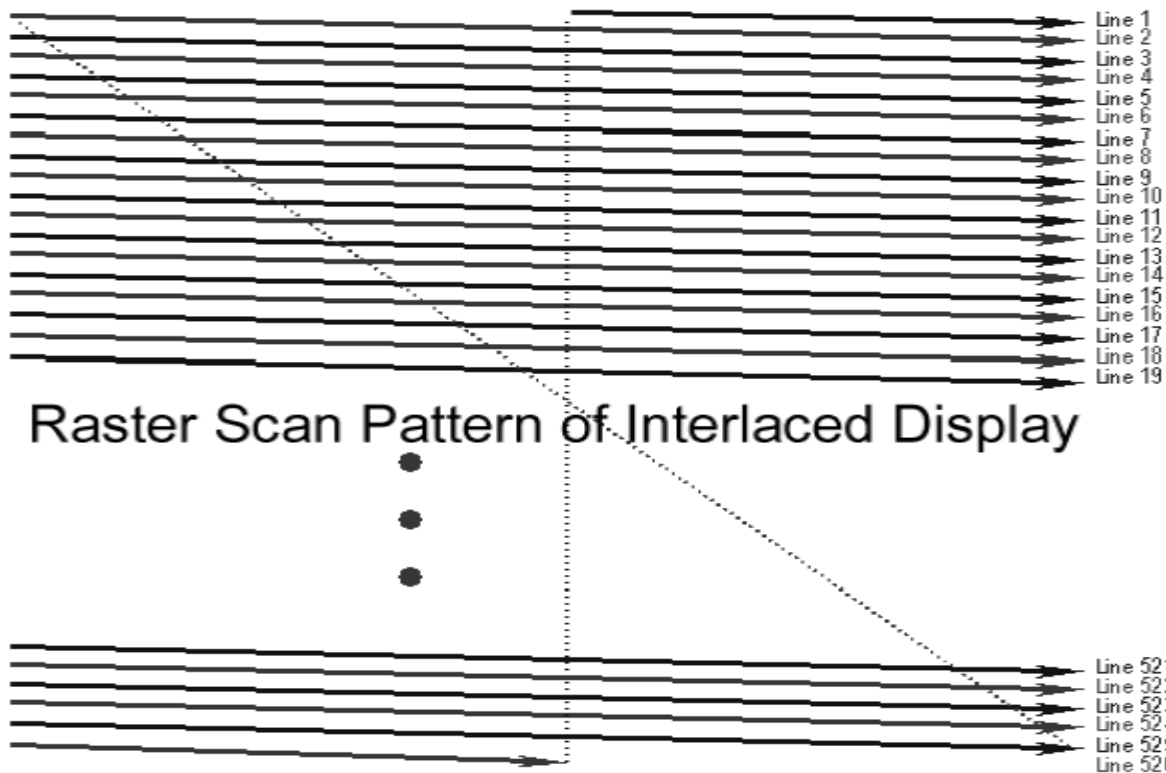
The return to the left of the screen, after refreshing each scan line, is called the Horizontal Retrace of the electron beam. And at the end of each frame (displayed in 1/80th to 1/60th of a second), the electron beam returns (vertical retrace) to the top left corner of the screen to begin the next frame.



On some raster-scan systems (and in TV sets), each frame is displayed in two passes using an INTERLACED refresh procedure. In the first pass, the beam sweeps across each other scan line from top to bottom. Then after the vertical retrace, the beam sweeps out the remaining scan line.

Interlacing of the scan line in this way allows us to see the entire screen displayed in one-half the time it would have taken to sweep across all the lines at once from top to bottom.

This is an effective technique for avoiding flicker, providing that adjacent scan lines contain similar display information



S.NO	RGPV QUESTIONS	Year	Marks
1.	Describe the working of raster refresh display tube. How different gray levels are incorporated in it?	June, 2010	10
2	Describe the working of raster refresh display tube. How different gray levels are incorporated in it?	Dec 2011	10
3	Explain the raster scan graphics. How do we generate a raster image? Also discuss the application areas of raster graphics.	June, 2012	10
4	What is Interlaced Scanning? Discuss in brief.	June, 2009	10
5	Consider a Non-Interlaced raster system with resolution of 1280 By 1024, a refresh rate of 60 Hz, a horizontal retrace time of 5 Microseconds and a vertical retrace time of 500 $\mu$ s. What is the fraction of the total refresh time per frame spent in horizontal retrace of the electron beam?	Dec 2013	10

## Storage tube displays

**Storage tube displays**

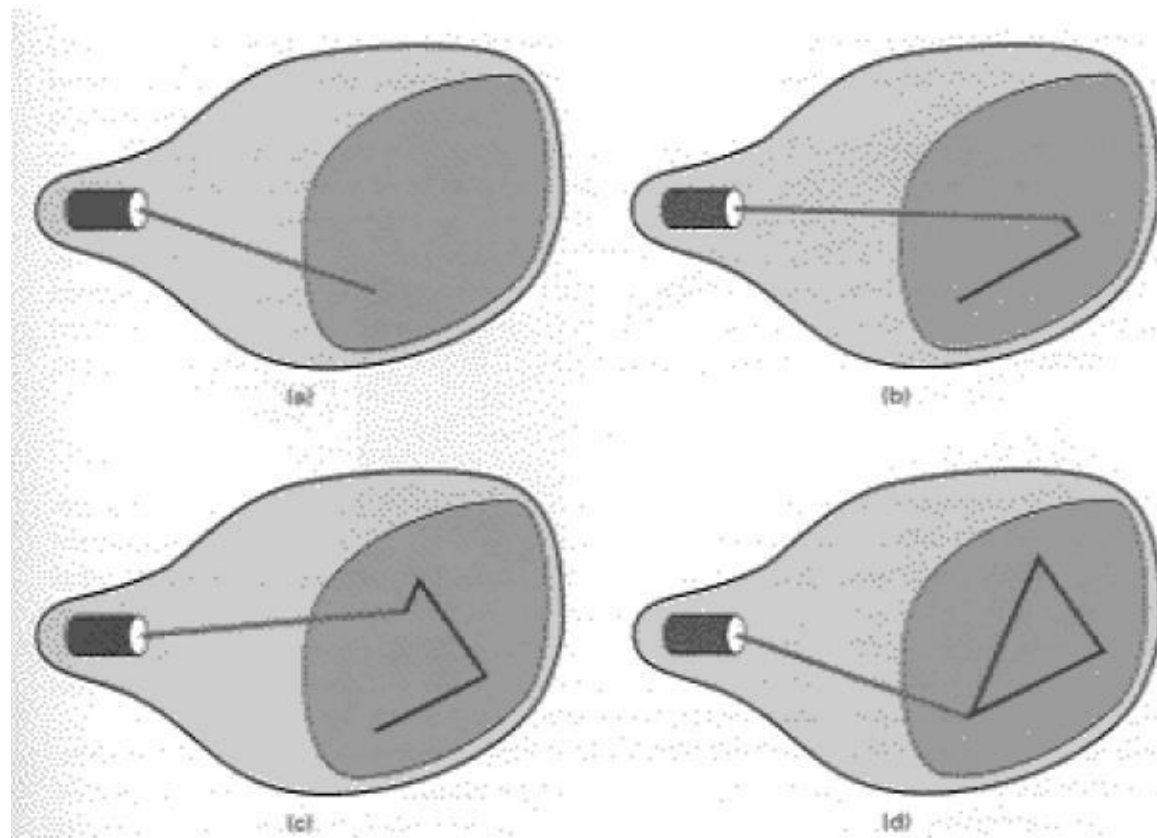
[RGPV /DEC-2013(5)]

When operated as a Random-Scan display unit, a CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn.

Random-Scan monitors draw a picture one line at a time and for this reason are also referred to as Vector Displays (or stroke-writing or calligraphic displays). The component lines of a picture can be drawn and refreshed by a random-scan system in any specified order. A Pen Plotter operates in a similar way and is an example of a random-scan, hard copy device.

Refresh rate of a random-scan system depends on the number of lines to be displayed. Picture definition is now stored as a set of line-drawing commands in an area of memory referred to as the Refresh Display File. It is also called as Display List, Display Program, and Refresh Buffer.

Random-Scan systems are designed for line-drawing applications and cannot display realistic shaded scenes



- The component lines of a picture can be drawn and refreshed by a random-scan system in any specified order (Fig.). A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.
- Refresh rate on a random-scan system depends on the number of lines to be displayed.
- Picture definition is now stored as a set of line drawing commands in an area of memory referred to as the refresh display file. Sometimes the refresh display file is called the display list, display program, or simply the refresh buffer.
- To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn. After all line drawing commands have been 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.
- High quality vector systems are capable of handling approximately 100,000 "short" lines at this refresh rate. When a small set of lines is to be displayed, each refresh cycle is delayed to avoid refresh rates greater than 60 frames per second. Otherwise, faster refreshing of the set of lines could burn out the phosphor.
- Random-scan systems are designed for line drawing applications and cannot display realistic shaded scenes. Since picture definition is stored as a set of line drawing instructions and not as a set of intensity values for all screen points, vector displays generally have higher resolution than raster systems.

S.NO	RGPV QUESTIONS	Year	Marks
1	Explain the concept of Calligraphic Display and Raster Refresh Display with its architecture?	Dec,2013	5

Refreshing, Flickering, Interlacing, Resolution

**Refreshing**

[RGPV /DEC-2012(5)]

The refresh rate (most commonly the "vertical refresh rate", "vertical scan rate" for cathode ray tubes) is the number of times in a second that display hardware updates its buffer. This is distinct from the measure of frame rate in that the refresh rate includes the repeated drawing of identical frames, while frame rate measures how often a video source can feed an entire frame of new data to a display. For example, most movie projectors advance from one frame to the next one 24 times each second. But each frame is illuminated two or three times before the next frame is projected using a shutter in front of its lamp. As a result, the movie projector runs at 24 frames per second, but has a 48 or 72 Hz refresh rate.

On cathode ray tube (CRT) displays, increasing the refresh rate decreases flickering, thereby reducing eye strain. However, if a refresh rate is specified that is beyond what is recommended for the display, damage to the display can occur.

For computer programs or telemetry, the term is also applied to how frequently a datum is updated with a new external value from another source

**Flickering**

Flicker is a visible fading between cycles displayed on video displays, especially the refresh interval on cathode ray tube (CRT) based computer screens. Flicker occurs on CRTs when they are driven at a low refresh rate, allowing the brightness to drop for time intervals sufficiently long to be noticed by a human eye – see persistence of vision and flicker fusion threshold. For most devices, the screen's phosphors quickly lose their excitation between sweeps of the electron gun, and the afterglow is unable to fill such gaps – see phosphor persistence. A similar effect occurs in PDPs during their refresh cycles.

For example, if a cathode ray tubes vertical refresh rate is set to 60 Hz, most screens will produce a visible "flickering" effect, unless they use phosphor with long afterglow. Most people find that refresh rates of 70–90 Hz and above enable flicker-free viewing on CRTs. Use of refresh rates above 120 Hz is uncommon, as they provide little noticeable flicker reduction and limit available resolution.

Since the shutters used in liquid crystal displays for each pixel stay at a steady opacity, they do not flicker, even when the image is refreshed. The backlights of such displays typically operate in the range of 150–250 Hz. But, to save the crystals from deterioration caused by constant current, voltage is constantly reversed, which may cause flicker. "In a pixel on an LCD monitor, the amount of light that is transmitted from the backlight depends on the voltage applied to the pixel. For the amount of light, it doesn't matter whether that voltage is negative or positive. However, applying the same voltage for a long period would damage the pixel.

For example, electricity decomposes water into oxygen and hydrogen gas. A comparable similar effect could happen inside the liquid crystals that are in the pixels. In order to prevent damage, LCD displays quickly alternate the voltage between positive and negative for each pixel, which is called 'polarity inversion'. Ideally, the rapid polarity inversion wouldn't be noticeable because every pixel has the same brightness whether a positive or a negative voltage is applied. However, in practice, there is a small difference, which means that every pixel flickers at about 30 hertz."

The lighting used in film projectors is typically an incandescent lamp or arc lamp, which does not flicker, but some degree of flicker is desirable to help decrease the flicker fusion threshold comfortably below film's typical frame rate of 24 fps. This is usually accomplished with a shutter which causes the lamplight to apparently strobe on and off at a multiple of the

frame rate, most often 48–96 Hz.

The exact refresh rate necessary to prevent the perception of flicker varies greatly based on the viewing environment. In a completely dark room, a sufficiently dim display can run as low as 30 Hz without visible flicker.[citation needed] At normal room and TV brightness this same display rate would produce flicker so severe as to be unwatchable.

### **Interlacing**

Interlacing (also known as interleaving) is a method of encoding a bitmap image such that a person who has partially received it sees a degraded copy of the entire image. When communicating over a slow communications link, this is often preferable to seeing a perfectly clear copy of one part of the image, as it helps the viewer decide more quickly whether to abort or continue the transmission.

Interlacing is a form of incremental decoding, because the image can be loaded incrementally. Another form of incremental decoding is progressive scan. In progressive scan the loaded image is decoded line for line, so instead of becoming incrementally clearer it becomes incrementally larger. The main difference between the interlace concept in bitmaps and in video is that even progressive bitmaps can be loaded over multiple frames.

For example: Interlaced GIF is a GIF image that seems to arrive on your display like an image coming through a slowly opening Venetian blind. A fuzzy outline of an image is gradually replaced by seven successive waves of bit streams that fill in the missing lines until the image arrives at its full resolution.

Interlaced graphics were once widely used in web design and before that in the distribution of graphics files over bulletin board systems and other low-speed communications methods. The practice is much less common today, as common broadband internet connections allow most images to be downloaded to the user's screen nearly instantaneously, and interlacing is usually an inefficient method of encoding images.

### **Resolution**

The display resolution of a digital television, computer monitor or display device is the number of distinct pixels in each dimension that can be displayed. It can be an ambiguous term especially as the displayed resolution is controlled by different factors in cathode ray tube (CRT), flat-panel display which includes liquid-crystal displays, or projection displays using fixed picture-element (pixel) arrays.

It is usually quoted as width × height, with the units in pixels: for example, "1024 × 768" means the width is 1024 pixels and the height is 768 pixels. This example would normally be spoken as "ten twenty-four by seven sixty-eight" or "ten twenty-four by seven six eight".

One use of the term "display resolution" applies to fixed-pixel-array displays such as plasma display panels (PDPs), liquid-crystal displays (LCDs), digital light processing (DLP) projectors, or similar technologies, and is simply the physical number of columns and rows of pixels creating the display (e.g. 1920 × 1080). A consequence of having a fixed-grid display is that, for multi-format video inputs, all displays need a "scaling engine" (a digital video processor that includes a memory array) to match the incoming picture format to the display.

S.NO	RGPV QUESTIONS	Year	Marks
1.	Define the following terms: <ul style="list-style-type: none"> <li>• Refresh rate</li> <li>• Update rate</li> <li>• Vertical and horizontal blanking interval</li> <li>• Fluorescence</li> </ul>	Dec,2011	10
2	Standard TV has 480 scan lines. If the aspect ratio is $\frac{3}{4}$ . what is the capacity of frame buffer needed if 2 bits per pixel is used?	Dec,2013	5

Colour monitors and Display processors

**Color CRT Monitors:**

[RGPV /DEC-2014(10)]

A CRT monitor displays color pictures by using a combination of phosphors that emit different colored light. By combining the emitted light from the different phosphors, a range of colors can be generated.

The two basic techniques for producing color displays with a CRT are the Beam-Penetration method and the Shadow-Mask method.

The Beam-Penetration method for displaying color pictures has been used with random-scan monitors.

- Two layers of phosphor, usually red and green, are coated onto the inside of the CRT screen, and are displayed color depends on how far the electron beam penetrates into the phosphor layers.
- At intermediate beam speeds, combinations of red and green light are emitted to show two additional colors, orange and yellow.

Since only 4 colors are possible, the quality of pictures is not as good as with other methods.

Shadow-Mask methods are commonly used in raster-scan systems because they produce a much wider range of colors than the beam-penetration method. A Shadow-Mask CRT has three phosphor color dots at each pixel position.

- One phosphor dot emits a red light, another emits a green light and the third emits a blue light. When the 3 beams pass through a hole in the shadow mask, they activate a dot triangle, which appears as a small color spot on the screen.
- In some low-cost systems, the electron beam can only be set to on or off, limiting displays to 8 colors.
- More sophisticated systems can set intermediate intensity levels for the electron beams, allowing several million different colors to be generated.
- Color CRTs in graphics systems are designed as RGB Monitors. 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.

**Direct-View Storage Tubes (DVST):**

A DVST stores the picture information as a charge distribution just behind the phosphor-coated screen. Two electron guns are used in a DVST. One, the primary gun, is used to store the picture pattern, the second, the flood gun, maintains the picture display.

Advantage: Since no refreshing is needed, very complex pictures can be displayed at very high resolutions without flicker.

Disadvantage: They ordinarily do not display color and that selected parts of a picture cannot be erased.

**Flat-Panel Displays:**

The term Flat-Panel display refers to a class of video displays that have reduced volume, weight and power requirements compared to a CRT. Example: small TV monitors, laptop, an advertisement board in elevators, etc. Flat-Panel displays are categorized into Emissive and Nonemissive displays.

**Emissive Devices:**

- The Emissive displays (or emitters) are devices that convert electrical energy into

light. Eg. Plasma panels, light-emitting diode, etc.

- Nonemissive displays (or nonemitters) use optical effects to convert sunlight or light from some other source into graphics patterns. The most important example is a liquid-crystal device.
- Plasma Panels, are also called Gas-Discharge Displays, are constructed by filling the region between two glass plates with a mixture of gases that usually includes neon. A series of vertical conducting ribbons is placed on one glass panel, and a set of horizontal ribbon is built into the other hand.
- Thin-Film Electroluminescent Displays are similar in construction to a Plasma Panel. The difference is that the region between the glass plates is filled with a phosphor, such as zincsulfide doped with manganese, instead of a gas.
- LED is a matrix of diodes arranged to form the pixel positions in the display and picture definition is stored in a refresh buffer.

### Nonemissive Devices:

Liquid-Crystal Displays (LCDs) are commonly used in small systems, such as calculators and portable laptop computers. They produce a picture by passing polarized light from the surroundings or from an internal light source through a liquid-crystal material that can be aligned to either block or transmit the light. Two types – Passive Matrix and Active Matrix LCDs.

### Three-Dimensional Viewing Devices:

They are devised using a technique that reflects a CRT image from a vibrating, flexible mirror. For example, in Medical applications it is used to analyse data from Ultrasonography, in Geological applications to analyse topological data.

### Stereoscopic and Virtual-Reality Systems:

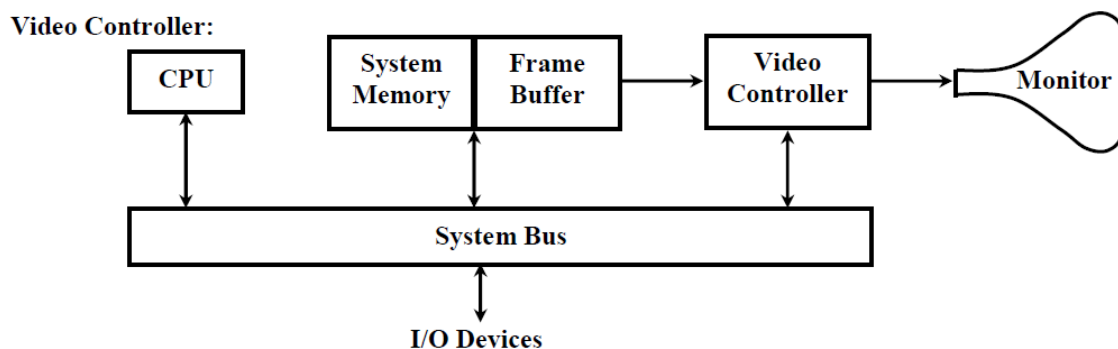
To represent objects in displaying Stereoscopic Views. This method does not produce true three-dimensional images, but it does provide a three-dimensional effect by presenting a different view to each eye of an observer so that scenes do appear to have depth.

Stereoscopic viewing is also a component in Virtual-Reality Systems, where users can step into a scene and interact with the environment

## RASTER-SCAN SYSTEMS

Interactive Raster graphics systems typically employ several processing units. In addition to the CPU, a special-purpose processor called the Video Controller or Display Controller is used to control the operation of the display device.

### Video Controller:



*Architecture of a Raster System*

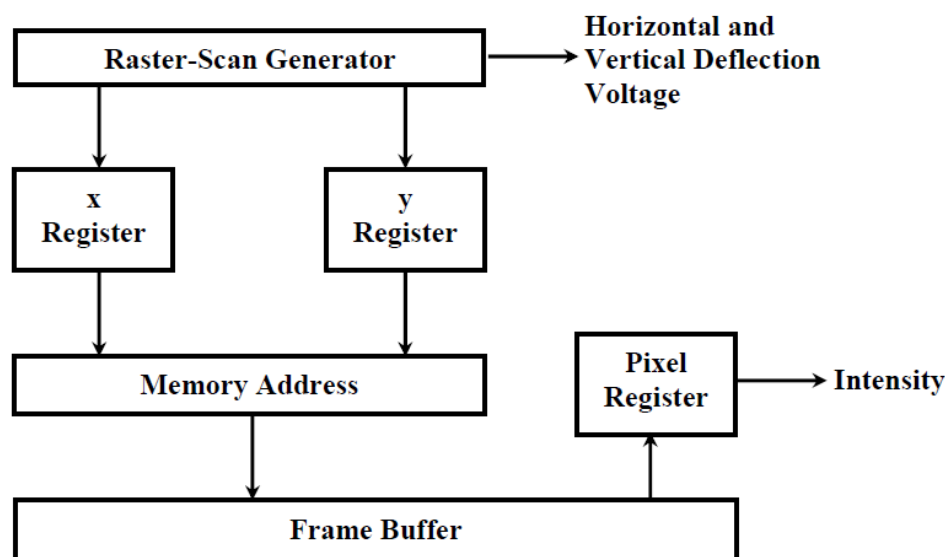
A fixed area of the system memory is reserved for the frame buffer, and the Video Controller is given direct access to the Frame-Buffer Memory.

Frame-Buffer locations and the corresponding screen positions are referred in Cartesian

Coordinates. For many graphics monitors, the coordinate origin is defined at the lower left screen corner. On some PC, origin is at upper left corner of the screen.

- Two registers are used to store the coordinates of the screen pixels. Initially, x register is set to 0 and y is set to ymax. The value stored in the frame buffer for this pixel position is then retrieved and used to set the intensity of the CRT beam. Then the x register is incremented by 1 and the process repeated for the next pixel on the top scan line. This procedure is repeated for each pixel along the scan line. After the last pixel on the top scan line has been processed, the x register is reset to 0 and y register is decremented by 1.
- After cycling through all pixels along the bottom scan line ( $y = 0$ ), the Video Controller resets the registers to the first pixel position on the top scan line and the refresh process starts again.
- Since the screen must be refreshed at the rate of 60 frames per second, the cycle time is too slow, this can't be accommodated by typical RAM chips. To speed up pixel processing, Video Controllers can retrieve multiple pixel values from the refresh buffer on each pass. When that group of pixels has been processed, the next block of pixel values is retrieved from the frame buffer. In high-quality systems, 2 frame buffers are often provided so that one buffer can be used for refreshing while the other is being filled with intensity values.

The basic refresh operations of the Video Controller are diagrammed below:



*Basic Video-Controller Refresh Operations*

### **Raster-Scan Display Processor:**

Display Processor is also referred as a Graphics Controller or a Display Coprocessor. The purpose of the display processor is to free the CPU from the graphics chores. In addition to the system memory, a separate display processor memory area can also be provided.

A major task of the display processor is digitizing 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. Similar methods are used for scan converting curved lines and polygon outlines. Characters can be defined with rectangular grids or they can be defined with curved outlines. The array size for character grids can vary from about 5 by 7 to 9 by 12 or more for higher-quality displays.

Display Processors are also designed to perform a number of additional operations. These

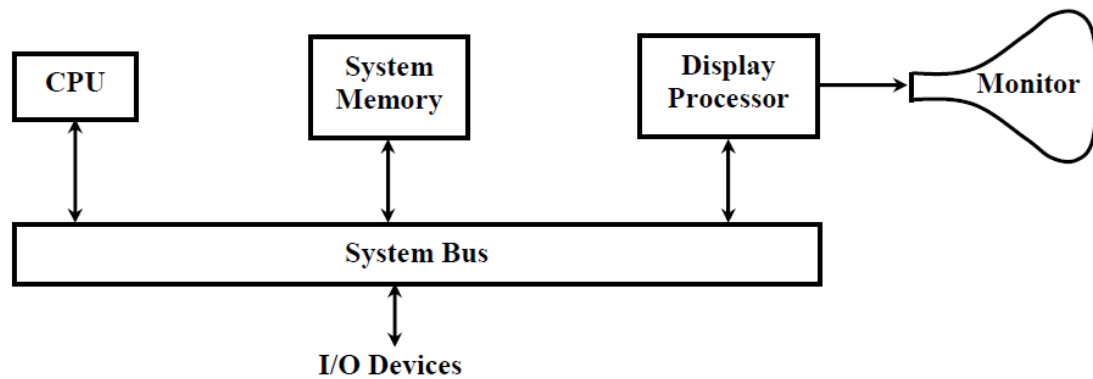
functions include generating various line styles (dashed, dotted or solid), displaying color areas and performing certain transformations and manipulations on displayed objects.

Also, display processors are typically designed to interface with interactive input devices, such as a mouse.

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 then 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. Sometimes the display processor in a Random-Scan system is referred to 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 endpoints, and these input coordinate values are converted to x and y deflection voltages.

#### RANDOM-SCAN SYSTEMS



S.NO	RGPV QUESTIONS	Year	Marks
1.	Write a short note on Direct View Storage Tube Display.	Dec,2012	10
2	What is the purpose of display processor in computer system?Give the architecture of a raster system with display processor.	Dec,2014	10



**INPUT DEVICES**

[RGPV /DEC-2012(5),Jun-2013(10)]

Various devices are available for data input on graphics workstations. Most systems have a keyboard and one or more additional devices include a mouse, trackball, spaceball, joystick, digitizers, dials, and button boxes. Some other input devices used in particular applications are data gloves, touch panels, image scanners, and voice systems.

**Keyboards:**

The Keyboard is an efficient device for inputting non graphic data as picture labels, i.e., for entering text strings. Cursor-control keys, Numeric pad and function keys are common features on general-purpose keyboards. Other types of cursor-positioning devices, such as a trackball or joystick, are included on some keyboards.

For specialized applications, input to a graphics application may come from a set of buttons, dials, or switches that select data values or customized graphics operations. Buttons and switches are often used to input predefined functions, and dials are common devices for entering scalar values.

Real numbers within some defined range are selected for input with dial rotations. Potentiometers are used to measure dial rotations, which are then converted to deflection voltages for cursor movement.

**Mouse:**

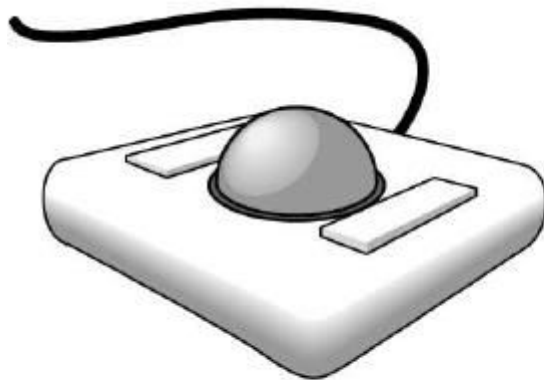
A mouse is small hand-held box used to position the screen cursor. Wheels or rollers on the bottom of the mouse can be used to record the amount and direction of movement.

Another method is the optical sensor, which detects movement across the lines in the grid. One, two, or three buttons are usually included on the top of the mouse for signaling the execution of some operation, such as recording cursor position or invoking a function.

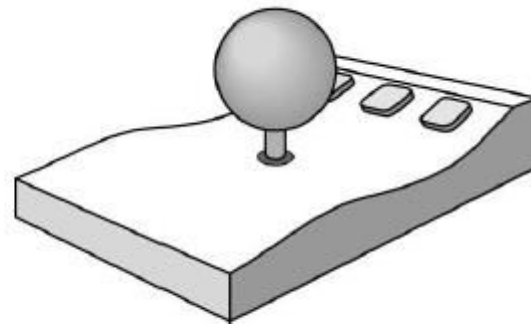
**Trackball and Spaceball:**

A Trackball is a ball that can be rotated with the fingers or palm of the hand, to produce screen-cursor movement. Trackballs are often mounted on keyboards and it is a two-dimensional positioning device.

A Spaceball provides six degrees of freedom. Unlike the trackball, a spaceball does not actually move. Spaceballs are used for three-dimensional positioning and selection operations in virtual-reality systems, modelling, animation, CAD, and other applications.



*Trackball*



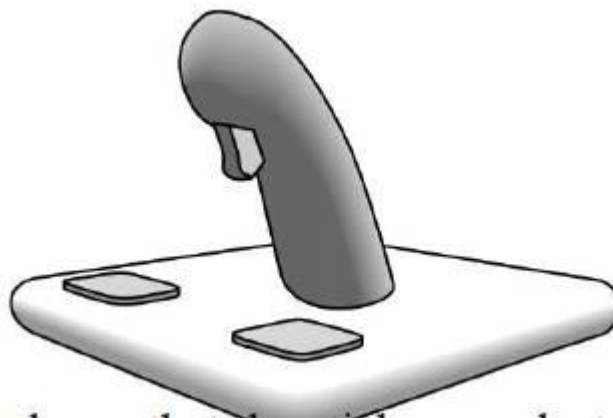
*Spaceball*

### **Joysticks:**

A Joystick consists of a small, vertical lever (called the stick) mounted on a base that is used to steer the screen cursor around. Most joysticks select screen positions with actual stick movement; others respond to pressure on the stick. Some are mounted on a keyboard; others function as stand-alone units.

In another type of movable joystick, 8 switches are arranged in a circle, so that the stick can select any one of eight directions for cursor movement.

Pressure-sensitive joysticks, also called Isometric Joysticks, have a no movable stick. Pressure on the stick is measured with strain gauges and converted to movement of the cursor in the direction specified.



### **Data Glove:**

A Data Glove that 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 antennas and receiving antennas is used to provide information about the position and orientation of the hand. A two-dimensional projection of the scene can be viewed on a video monitor, or a three-dimensional projection can be viewed with a headset.

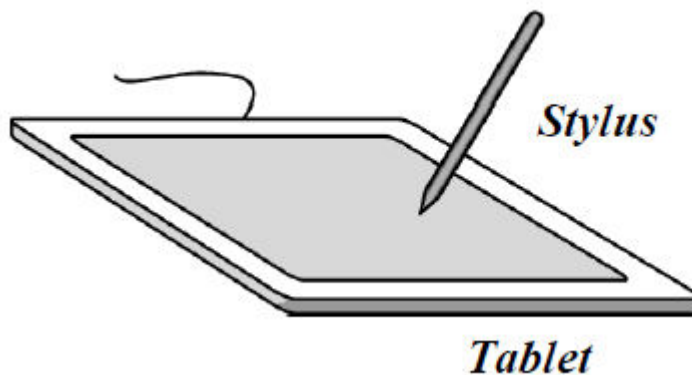


**Digitizers:**

A common device for drawing, painting, or interactively selecting coordinate positions on an object is a Digitizer. These devices can be used to input coordinate values in either a two-Stylus dimensional or a three-dimensional space. One type of digitizer is the graphics tablet (data tablet), which is used to input two-dimensional coordinates by activating a hand cursor or stylus at selected positions on a flat surface. A hand cursor contains cross hairs for sighting positions, while a stylus is a Tablet pencil-shaped device that is pointed at positions on the tablet.

Graphics tablets provide a highly accurate method for selecting coordinate positions, with an accuracy that varies from about 0.2 mm on desktop models to about 0.05 mm or less on larger models.

Many graphics tablets are constructed with a rectangular grid of wires embedded in the tablet surface. Depending on the technology, either signal strength, coded pulses, or phase shifts can be used to determine the position on the tablet. Three-dimensional digitizers use sonic or electromagnetic transmissions to record positions. Resolution of this system is from 0.8 mm to 0.08 mm, depending on the model.



S.NO	RGPV QUESTION	YEAR	MARKS
1.	Explain the working of following devices <ul style="list-style-type: none"> <li>• Keyboard</li> <li>• Trackball and Spaceball</li> </ul>	June 2013,Dec,2012	5,10

## UNIT 1/LECTURE 7

### HARDCOPY DEVICES

#### Image Scanners:

Drawings, graphs, color and black-and-white photos, or text can be stored for computer processing with an Image Scanner by passing an optical scanning mechanism over the information to be stored. We can also apply various transformations, image-processing methods to modify the array representation of the picture.

#### Touch Panels:

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

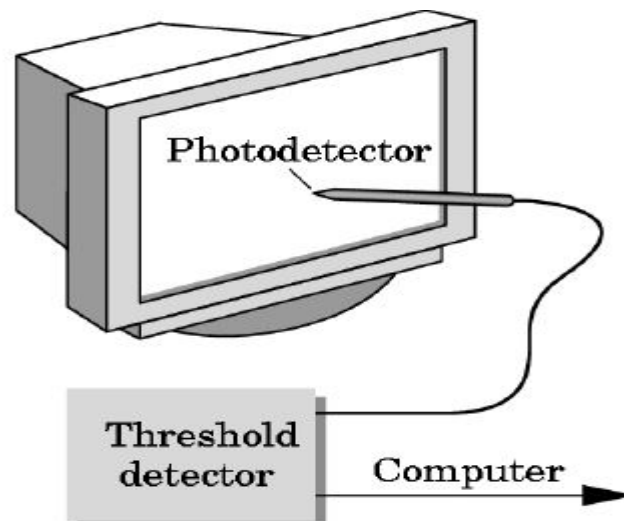
Touch input can be recorded using optical, electrical, or acoustical methods.

- Optical Touch Panels employ a line of infrared light-emitting diodes (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.
- An Electrical Touch Panel is constructed with two 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 selected screen position.
- In Acoustical Touch Panels, high-frequency sound waves are generated in the horizontal and vertical directions across a glass plate.

#### Light Pens

Light Pen is a pencil-shaped device used to select screen positions by detecting the light coming from points on the CRT screen. Light Pens sometimes give false readings due to background lighting in a room.

The pen will send a pulse whenever phosphor below it is illuminated. While the image on a refresh display may appear to be stable, it is in fact blinking on and off faster than the eye can detect. This blinking is not too fast, for the light pen. The light pen as easily determines the time at which the phosphor is illuminated. Since there is only one electron beam on the refresh display, only one line segment can be drawn at a time and no two segments are drawn simultaneously.



## Voice Systems

Speech recognizers are used in some graphics workstations as input devices to accept voice commands. The Voice-System input can be used to initiate graphics operations or to enter data. These systems operate by matching an input against a predefined dictionary of words and phrase.

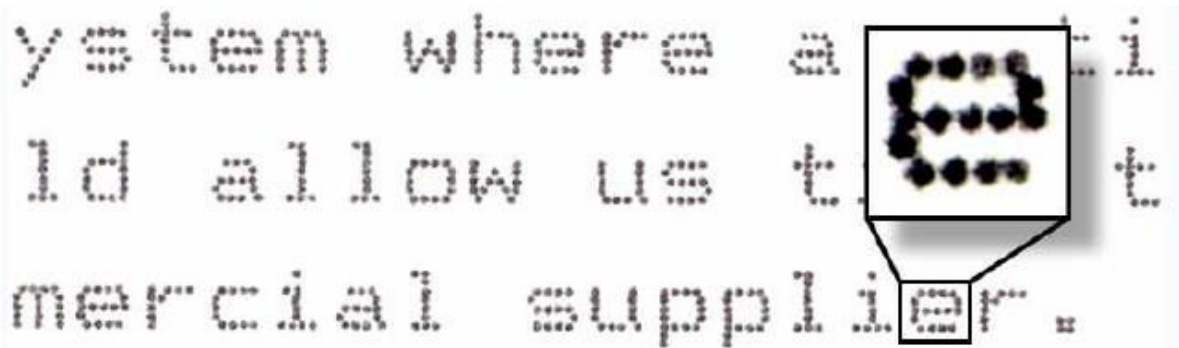
## HARD-COPY DEVICES:

We can obtain hard-copy output for various images in several formats. The most important output device is Printer or Plotter and many types are there.

Printers produce output by either Impact or Nonimpact methods.

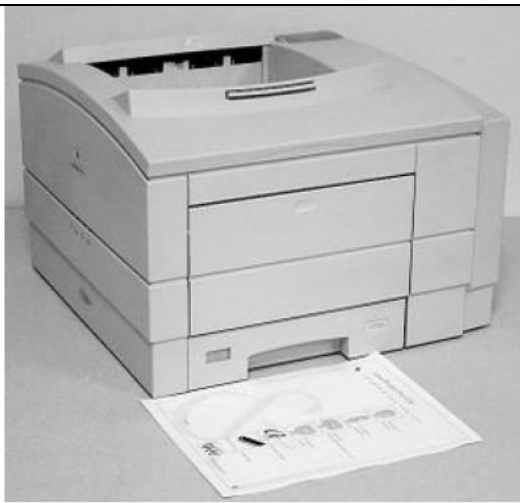
**Impact Printers** press formed character faces against an inked ribbon onto the paper. E.g. : Line Printer, with the typefaces mounted on bands, chains, drums, or wheels.

- Character impact printers often have a Dot-Matrix print head containing a rectangular array of protruding wire pins, with the number of pins depending on the quality of the printer.



**Nonimpact Printers** and plotters use laser techniques, ink-jet sprays, xerographic processes (photocopying), electrostatic methods, and electro thermal methods to get images onto Paper.

- In a Laser Device, a laser beam mates a charge distribution on a rotating drum coated with a photoelectric material, such as selenium. Toner is applied to the drum and then transferred to paper.
- Ink-Jet 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 patterns.



*Laser Printer*



*Inkjet Printer*

- 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 so is attracted to the negatively charged areas, where it adheres to produce the specified output.
- Electrothermal methods use heat in a dot-matrix print head to output patterns on heat sensitive paper. We can get limited color output on an impact printer by using different colored ribbons.

Nonimpact devices use various techniques to combine three color pigments (cyan, magenta, and yellow) to produce a range of color patterns.

- Laser and Xerographic devices deposit the three pigments on separate passes; ink-jet methods shoot the three colors simultaneously on a single pass along each print line on the paper.
- Drafting layouts and other drawings are typically generated with ink-jet or pen plotters.

**A Pen Plotter** has one or more pens mounted on a carriage, or crossbar, that spans a sheet of paper. Pens with varying colors and widths, wet-ink, ball-point, and felt-tip pens are all possible choices for use with a pen plotter. Crossbars can be either moveable or stationary, while the pen moves back and forth along the bar. E.g.: flatbed pen plotter, rollfed pen plotter.



S.NO	RGPV QUESTION	YEAR	MARKS
1.	Explain the working of following devices <ul style="list-style-type: none"><li>• Printer</li><li>• Touchpanel</li><li>• Lightpen</li></ul>	June 2012	10
2	Differentiate between impact and non impact printer	Dec,2010	10

## UNIT 1/LECTURE 8

### Graphical Input Techniques

#### INPUT OF GRAPHICAL DATA:

Graphics programs use several kinds of input data. Picture specifications need values for coordinate positions, values for the character-string parameters, scalar values for the transformation parameters, values specifying menu options, and values for identification of picture parts.

To make graphics packages independent of the particular hardware devices used, input functions can be structured according to the data description to be handled by each function. This approach provides a logical input-device classification in terms of the kind of data to be input by the device.

#### Logical Classification of Input Devices:

The various kinds of input data are summarized in the following six logical device classifications used by PHIGS and GKS:

- |            |   |  |
|------------|---|--|
| LOCATOR    | – | a device for specifying a coordinate position (x, y)     |
| STROKE     | – | a device for specifying a series of coordinate positions |
| STRING     | – | a device for specifying text input                       |
| VALUATOR – |   | a device for specifying scalar values                    |
| CHOICE     | – | a device for selecting menu options                      |
| PICK       | – | a device for selecting picture components                |

#### Locator Devices:

A standard method for interactive selection of a coordinate point is by positioning the screen cursor. We can do this with a mouse, joystick, trackball, spaceball, thumbwheels, dials, a digitizer stylus or hand cursor, or some other cursor-positioning device. When the screen cursor is at the desired location, a button is activated to store the coordinates of that screen point.

Keyboards can be used for locator input in several ways. A general-purpose keyboard usually has four cursor-control keys that move the screen cursor up, down, left, and right.

Alternatively, a joystick, joydisk, trackball, or thumbwheels can be mounted on the keyboard for relative cursor movement.

Light pens have also been used to input coordinate positions, but some special implementation considerations are necessary. Since light pens operate by detecting light emitted from the screen phosphors, some nonzero intensity level must be present at the coordinate position to be selected.

#### Stroke Devices:

This class of logical devices is used to input a sequence of coordinate positions.

Stroke-device input is equivalent to multiple calls to a locator device. The set of input points is often used to display line sections.

Continuous movement of a mouse, trackball, joystick, or tablet hand cursor is translated into a series of input coordinate values.

The graphics tablet is one of the more common stroke devices. Button activation can be used to place the tablet into “continuous” mode. As the cursor is moved across the tablet surface, a stream of coordinate values is generated. This process is used in paintbrush systems that allow artists to draw scenes on the screen and in engineering systems where layouts can be traced and digitized for storage.

#### String Devices:

The primary physical device used for string input is the keyboard. Input character strings are typically used for picture or graph labels.



Other physical devices can be used for generating character patterns in a “text-writing” mode. For this input, individual characters are drawn on the screen with a stroke or locator-type device.

### **Valuator Devices:**

These devices are employed in graphic systems to input scalar values. Valuator devices are used for setting various graphics parameters, such as rotation angle and scale factors, and for setting physical parameters associated with a particular application (temperature settings, voltage levels, stress factors, etc.).

A typical physical device used to provide valuator input is a set of control dials. Floating-point numbers within any predefined range are input by rotating the dials.

Dial rotations in one direction increase the numeric input value, and opposite rotations decrease the numeric value. Rotary potentiometers convert dial rotation into a corresponding voltage. This voltage is then translated into a real number within a defined scalar range, such as -10.5 to 25.5. Instead of dials, slide Potentiometers are sometimes used to convert linear movements into scalar values.

Joystick, trackball, tablets, and other interactive devices can be adapted for valuator input by interpreting pressure or movement of the device relative to a scalar range.

Another technique for providing valuator input is to display sliders, buttons, rotating scales, and menus on the video monitor.

### **Choice Devices:**

Graphics packages use menus to select programming options, parameter values, and object shapes to be used in constructing a picture.

A choice device is defined as one that enters a selection from a list (menu) of alternatives. Commonly used choice devices are a set of buttons; a cursor positioning device, such as a mouse, trackball, or keyboard cursor keys; and a touch panel.

For screen selection of listed menu options, we can use cursor-control devices. When a coordinate position (x, y) is selected, it is compared to the coordinate extents of each listed menu item. A menu item with vertical and horizontal boundaries at the coordinate values xmin, xmax, ymin and ymax is selected if the input coordinates (x, y) satisfy the inequalities

For larger menus with a few options displayed at a time, a touch panel is commonly used.

Alternate methods for choice input include keyboard and voice entry. A standard keyboard can be used to type in commands or menu options.

Similar coding can be used with voice-input systems. Voice input is particularly useful when the number of options is small (20 or less).

### **Pick Devices:**

Pick devices are used to select parts of a scene that are to be transformed or edited in some way.

- Typical devices used for object selection are the same as those for menu selection: the cursor-positioning devices.
- With a mouse or joystick, we can position the cursor over the primitives in a displayed structure and press the selection button. The position of the cursor is then recorded, and several levels of search may be necessary to locate the particular object (if any) that is to be selected.

First, the cursor position is compared to the coordinate extents of the various structures in the scene.

S.NO	RGPV QUESTION	YEAR	MARKS
1.	Write a short note on Pointing and Positioning Devices	Dec,2013	10

## UNIT 1/LECTURE 9

### GRAPHICAL INPUT FUNCTIONS

#### INPUT FUNCTIONS

Graphical input functions can be set up to allow users to specify the following options:

Which physical devices are to provide input within a particular logical classification (for example, a tablet used as a stroke device). How the graphics program and devices are to interact (input mode). Either the program or the devices can initiate data entry, or both can operate simultaneously. When the data are to be input and which device is to be used at that time to deliver a particular input type to the specified data variables.

#### Input Modes:

Functions to provide input can be structured to operate in various input modes, which specify how the program and input devices interact. Input could be initiated by the program, or the program and input devices both could be operating simultaneously, or data input could be initiated by the devices. These three input modes are referred to as request mode, sample mode, and event mode.

- In request mode, the application program initiates data entry. Input values are requested and processing is suspended until the required values are received.
- In sample mode, the application program and input devices operate independently. Input devices may be operating at the same time that the program is processing other data.
- In event mode, the input devices initiate data input to the application program. The program and the input devices again operate concurrently, but now the input devices deliver data to an input queue. All input data are saved. When the program requires new data, it goes to the data queue.

An input mode within a logical class for a particular physical device operating on a specified workstation is declared with one of six input-class functions of the form.

#### Request Mode:

Input commands used in this mode correspond to standard input functions in a high-level programming language. When we ask for an input in request mode, other processing is suspended until the input is received. Input requests can be made to that device using one of the six logical-class functions represented by the following:

```
request . . . (ws, device code, status, . . . .)
```

Values input with this function are the workstation code and the device code. Returned values are assigned to parameter status and to the data parameters corresponding to the requested logical class. A value of ok or nonc are returned in parameter status, according to the validity of the input data. A value of none indicates that the input device was activated so as to produce invalid data.

A returned value of none can be used as an end-of-data signal to terminate a programming sequence.

#### Locator and Stroke Input in Request Mode

The request functions for these two logical input classes are:

```
requestLocator (ws, devcode, status , viewIndex, pt) requestStroke (ws, devCode,  
nMax, status , viewIndex, n , pts)
```

For locator input, pt is the world-coordinate position selected. For stroke input, pts is a list of n coordinate positions, where parameter nMax gives the maximum number of points that can go in the input list. Parameter viewIndex is assigned the two-dimensional view index number.

Determination of a world-coordinate position is a two-step process: (1) The physical device

selects a point in device coordinates (usually from the video-display screen) and the inverse of the workstation transformation is performed to obtain the corresponding point in normalized device coordinates. (2) Then, the inverse of the window-to-viewport mapping is carried out to get to viewing coordinates, then to world coordinates.

Since two or more views may overlap on a device, the correct viewing transformation is identified according to the view-transformation input priority number. View index 0 has the highest priority.

**Sample Mode:**

Once sample mode has been set for one or more physical devices, data input begins without waiting for program direction. Sampling of the current values from a physical device in this mode begins when a sample command is encountered in the application program. A locator device is sampled with one of the six logical-class functions represented by the following:

sample . . . (ws, deviceCode, . . .)

A final translation position for the object can be obtained with a locator, and the rotation angle can be supplied by a valuator device, as demonstrated in the following statements.

sampleLocator (wsl, devl, viewIndex, pt)

sampleValuator (ws2, dev2, angle)

**Event Mode:**

When an input device is placed in event mode, the program and device operate simultaneously. Data input from the device is accumulated in an event queue, or input queue. All input devices active in event mode can enter data (referred to as "events") into this single-event queue, with each device entering data values as they are generated. An application program can be directed to check the event queue for any input with the function awaitEvent (time, ws, deviceClass, deviceCode)

S.NO	RGPV QUESTION	YEAR	MARKS
1	Explain the types of graphical input modes with their function.	Dec,2012	10

There are several techniques that are incorporated into graphics packages to aid the interactive construction of pictures. Input coordinates can establish the position or boundaries for objects to be drawn, or they can be used to rearrange previously displayed objects.

**Basic Positioning Methods:**

Coordinate values supplied by locator input are often used with positioning methods to specify a location for displaying an object or a character string. We interactively select coordinate positions with a pointing device, usually by positioning the screen cursor.

For lines, straight line segments can be displayed between two selected screen positions. As an aid in positioning objects, numeric values for selected positions can be echoed on the screen. Using the echoed coordinate values as a guide, we can make adjustments in the selected location to obtain accurate positioning.

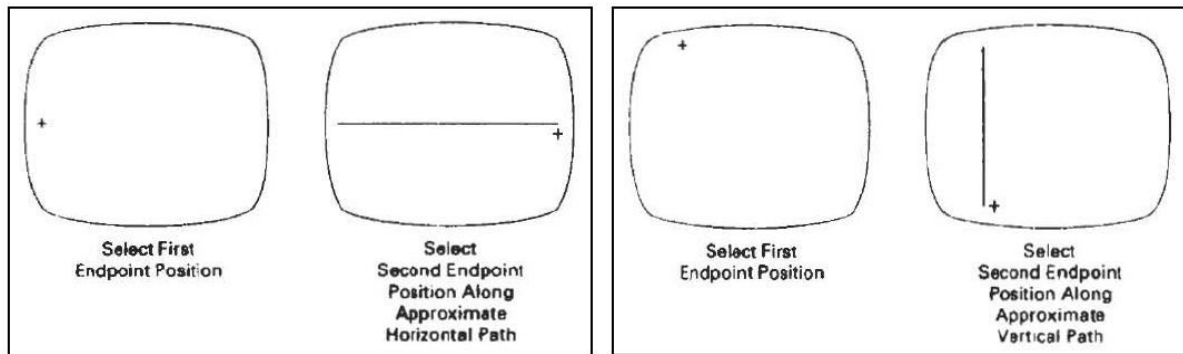
**Constraints:**

With some applications, certain types of prescribed orientations or object alignments are useful. A constraint is a rule for altering input-coordinate values to produce a specified orientation or alignment of the displayed coordinates. There are many kinds of constraint functions that can be specified, but the most common constraint is a horizontal or vertical alignment of straight lines. This type of constraint, shown in the following diagrams, is useful in forming network layouts.

With this constraint, we can create horizontal and vertical lines without worrying about precise specification of endpoint coordinates.

A horizontal or vertical constraint is implemented by determining whether any two input coordinate endpoints are more nearly horizontal or more nearly vertical. If the difference in the y values of the two endpoints is smaller than the difference in x values, a horizontal line is displayed. Otherwise, a vertical line is drawn.

Other kinds of constraints can be applied to input coordinates to produce a variety of alignments. Lines could be constrained to have a particular slant, such as 45", and input coordinates could be constrained to lie along predefined paths, such as circular arcs.



*Horizontal Line Constraint*

*Vertical Line Constraint*

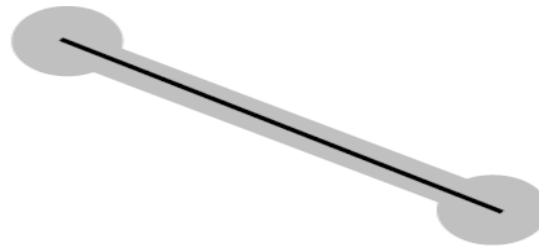
**Grids:**

Another kind of constraint is a grid of rectangular lines displayed in some part of the screen area. When a grid is used, any input coordinate position is rounded to the nearest intersection of two grid lines.

**Gravity Field:**

In the construction of figures, we sometimes need to connect lines at positions between endpoints. Since exact positioning of the screen cursor at the connecting point can be difficult, graphics packages can be designed to convert any input position near a line to a position on the line. This conversion of input position is accomplished by creating a gravity field area around the line. Any selected position within the gravity field of a line is moved ("gravitated") to the nearest position on the line.

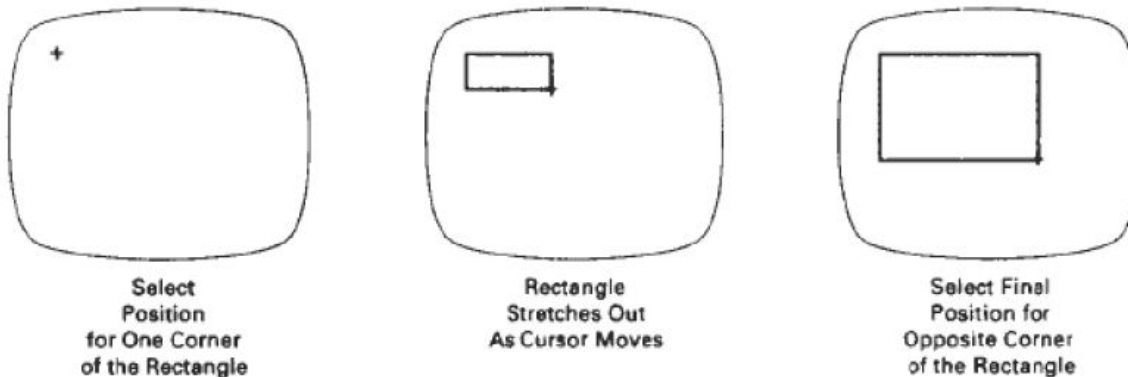
A gravity field area around a line is illustrated with the shaded boundary as shown in the diagram. Areas around the endpoints are enlarged to make it easier for us to connect lines at their endpoints. Selected positions in one of the circular areas of the gravity field are attracted to the endpoint in that area. If many lines are displayed, gravity areas can overlap, and it may be difficult to specify points correctly. Normally, the boundary for the gravity field is not displayed



**Rubber-Band Method:**

Straight lines can be constructed and positioned using Rubber-Band methods, which stretch out a line from a starting position as the screen cursor is moved. The following figure demonstrates the rubber-band method.

We first select a screen position for one endpoint of the line. Then, as the cursor moves around, the line is displayed from the start position to the current position of the cursor. When we finally select a second screen position, the other line endpoint is set. Rubber-band methods are used to construct and position other objects besides straight lines.



*Fig. (a) Rubber-Band method for constructing a Rectangle*

**Dragging:**

A technique that is often used in interactive picture construction is to move objects into position by dragging them with the screen cursor. We first select an object, and then move the cursor in the direction we want the object to move, and the selected object follows the cursor path.

**Painting and Drawing:**

Options for sketching, drawing, and painting come in a variety of forms. Curve-drawing options can be provided using standard curve shapes, such as circular arcs and splines, or with freehand sketching procedures. Splines are interactively constructed by specifying a set of discrete screen points that give the general shape of the curve. Then the system fits the set of points with a polynomial curve. In freehand drawing, curves are generated by following the path of a stylus on a graphics tablet or the path of the screen cursor on a video monitor. Once a curve is displayed, the designer can alter the curve shape by adjusting the positions of selected points along the curve path.

S.NO	RGPV QUESTION	YEAR	MARKS
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1	Define following <ul style="list-style-type: none"><li>• Dragging</li><li>• Positioning</li><li>• Rubber band technique</li></ul>	June 2012	10
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