SHRIMATI INDIRA GANDHI COLLEGE

(NATIONALLY ACCREDITED AT “A” GRADE (3RDCYCLE) BY NAAC)

TIRUCHIRAPPALLI-2

TUTORIAL MATERIAL

COMPUTER GRAPHICS

DEPARTMENT OF COMPUTER SCIENCE

COMPUTER GRAPHICS

INTRODUCTION

UNIT-1

2 MARKS :

1. **Define Refresh CRT.**

One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same points. This type of display is called a refresh **CRT.**

2. **What is Resolution ?**

The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution.

3. **Define Persistence.**
   - Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity.
   - Although some phosphors have a persistence greater than 1 second, Graphics monitors are usually constructed with persistence in the range from 10 to 60 microseconds.
4. **Define Aspect Ratio.**
   - Another property of video monitors is aspect ratio. This number gives the ratio of vertical points to horizontal points necessary to produce equal length lines in both directions on the screen.

     X=Vertical points/Horizontal points;
   - An aspect ratio of 3/4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.
5. **Define Refresh Buffer.**
   - 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".**
6. **Write short note on Bitmap & Pixmap.**
   - 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 pix map.

7. **Name some Input devices.**

- Key board
- Mouse
- Scanner
- Touch Screen
- Joy Stick
- Light pen
- Track ball
- Optical Character Reader(OCR)
- Optical Mark Reader(OMR)
- Magnetic Ink Character Reader(MICR)
- Barcode Reader
- Digital Camera & Tablets

8. Name Some Output Devices.

- Monitors
- Plotter
- Printer

9. What is Run length Encoding?

One number of each pair indicates an intensity value, second number specific the number of adjacent pixels, this technique is called as run length encoding.

10. What is Work Station?

Work Station is nothing but a System. It cannot be Stored in Memory or System and to Store only in Server.

11. Define Output primitives.

The basic elements constituting a graphic are called output primitives. GRPH1 has the following output primitives.

- Polyline
- Polymarker
- Text
- Tone

12. What are the types of lines?

Line types indicate solid, dashed, and doted lines. The following line types are allotted to numbers 1 through 4.

- Solid
- Dashed
- Dotted

- Alternate long and short dash

13. Define DDA ALGORITHM.

The digital differential analyzer (DDA) samples the line at unit intervals in one coordinate corresponding integer values nearest the line path of the other coordinate.

14. Explain about Bresenham's Line Algorithm.

An accurate, efficient raster line drawing algorithm developed by Bresenham, scan converts lines using only *incremental integer* calculations that can be adapted to display circles and other curves.
Keeping in mind the symmetry property of lines, lets derive a more efficient way of drawing a line.

15. What are the Attributes of Output Primitives?

Any parameter that affects the way a primitive is to be displayed is referred to as an attribute parameter. Example attribute parameters are color, size etc. A line drawing function for example could contain parameter to set color, width and other properties.

1. Line Attributes
2. Area Fill Attributes
3. Character Attributes
4. Bundled Attributes

16. What is a Filled area primitive?

Options for filling a defined region include a choice between a solid colour or a pattern fill and choices for particular colours and patterns.

17. Define Line Function.

A procedure for specifying stratight line segments can be set up in a number of different forms. In PHIGS,GKS and some other packages . the two-dimensional line function is **polyline (n,wspoints)**

18 . Define Parallel Curve Algorithm.

A parallel of a curve is the envelope of a family of congruent circles centered on the curve. It generalises the concept of parallel lines. It can also be defined as a curve whose points are at a *fixed normal distance* from a given curve.

19. Define Pixel Addressing.

Several coordinate references associated with the specification and generation of a picture. Object descriptions are given in a world reference frame, chosen to suit a particular application and input world coordinates are ultimately converted to screen display positions.

20. Define Bundled Attributes.

A particular set of attribute values for a primitive on each output device is then chosen by specifying the appropriate table index. Attributes specified in this manner are called Bundled attributes.

21. Define Antialiasing.

Displayed primitives generated by the raster algorithms have a jagged or stairstep, appearance because the sampling process digitizes coordinate points on an object to discrete integer pixel positions. This distortion of information due to low frequency sampling is called aliasing. To improve the appearance of displayed raster lines by applying antialiasing methods that compensate for the under sampling process

5 MARKS:-

1. Discuss about Raster-Scan Display.

Procedure:

- The most common type of graphics monitor employing a CRT is the raster-scan display, based on television technology.
- In a raster-scan system, 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.
- The capability of a raster-scan system to store intensity information for each screen point makes it well suited for the realistic display of scenes containing subtle shading and color patterns. Stored **intensity values** are then retrieved from the **refresh buffer** and "painted" on the screen one row (scan line) at a time.

o Refreshing on raster-scan displays is carried out at the rate of 60 to 80 frames per second, although some systems are designed for higher refresh rates. Sometimes, refresh rates are described in units of cycles per second, or Hertz (Hz), where a cycle corresponds to one frame. Using these units, we would describe a refresh rate of ***60*** frames per second as simply 60 Hz.

- **'Interlacing of the scan lines 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. Interlacing is primarily used with slower refreshing rates.

Example:

"**Home television sets"** and "**printers"** are examples of other systems using raster-scan methods.

Refresh buffer or Frame buffer:

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. Each screen point is referred to as a **"pixel or pel".**

BIT MAP & PIX MAP:

- On a black & 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 pix map.

2. Explain about Random-Scan Display.

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.

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.

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. **Also,** vector displays produce smooth line drawings **because** the CRT beam directly follows the line path. **A** raster system, in contrast, produces **jagged lines** that are plotted as the point sets.

Example: A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.

3. **Explain about Direct View Storage Tubes**.

An alternative 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 (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".**

DVST Types:

- Primary gun;
- Flood gun;

Advantages:

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

Disadvantages:

Disadvantages of DVST systems are that they ordinarily do not display color and that selected parts of a picture cannot he 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.

4. **What are the two methods of Color CRT Monitors?**

A CRT monitor displays color pictures by using a combination of phosphors that Emitted 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:

The beam-penetration method for displaying color pictures has been used with random-scan monitors. Two layers of phosphor, usually red and green, are **A** random-scan system draws the component **lines** of an **object** in any order specified coated onto the inside of the CRT screen, and the displayed color depends 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 beam 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 four colors are possible, and the quality of pictures is not as good as with other methods.

Shadow-mask method:

Shadow-mask methods **are** commonly **used** in raster scan systems (including color **TV)** because they produce a much wider range of color 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".** This type of CRT has three electron guns, one for each color dot, and a shadow-mask grid just behind the phosphor-coated screen. The delta shadow-mask method, commonly used in Color **CRT** systems.

Three electron **guns,** aligned with the triangular color dot patterns on the **screen,**are **directed** to each dot triangle **by** a shadow mask. Another configuration for the three electron guns is an ***in-line*** arrangement in which the three electron guns, and the Corresponding red-green-blue color dots on the screen, are aligned along one scan line instead of in a triangular pattern. By turning off the **red** and green **guns,** we get only the color coming the blue phosphor.

A white (or gray) area is the result of activating all three dots with equal intensity. Yellow is produced with the green and red dots only, magenta is produced with the blue and red dots, and cyan shows up when blue and green are activated equally. In some low-cost systems, the electron beam can only be set to on or off, limiting displays to eight colors.

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, and blue) directly from the computer system without any intermediate processing. High-quality raster-graphics systems have 24 bits per pixel in the same buffer, allowing **256** voltage settings for each electron gun and nearly 17 million color choices for each 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.

5. Explain in detail about Output Devices.

- Monitors
- Printers
- Plotters

Monitors:

- There are two types Black and White screen and color screen.
- The screen size will be 24 lines,80 columns and using text, character, images etc…

Printers & Plotters:

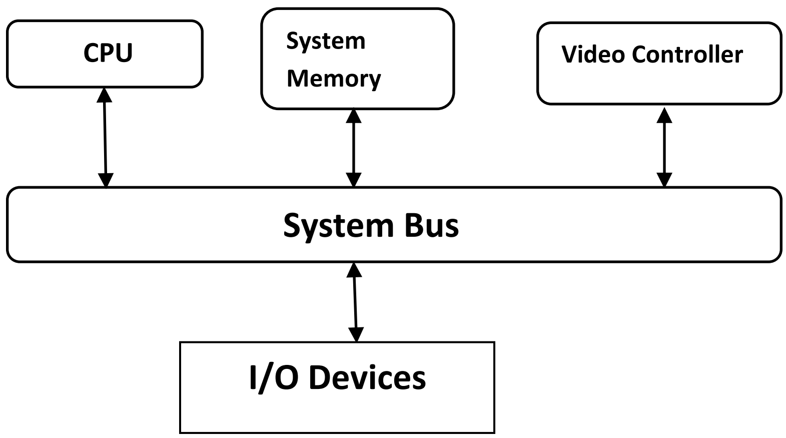
Printers produce output by either impact or nonimpact methods. Impact Printers press formed character faces against an inked ribbon onto the paper. **A** Line printer is an example of an impact device, with the typefaces mounted on bands, chains, drums, or wheels. ***Non impact*** printers and plotters use laser techniques, Ink-jet sprays, xerographic presses (as used in photocopying machines), electrostatic methods, and electro thermal methods to get images onto Paper. Character impact printers often have a ***dot-matrix*** print head containing a rectangular array of producing ***wire*** pins, with the number of pins depending on the quality of the printer.

Electro thermal 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 tine on the paper.

Ink-jet methods produce output by squirt in 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.

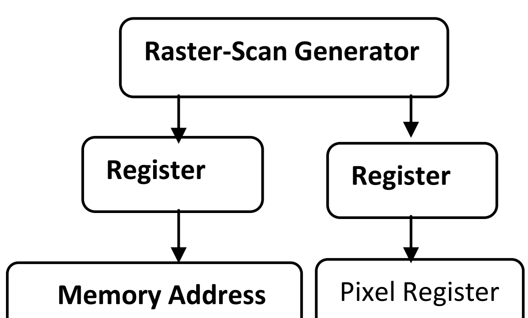
- Interactive raster graphics systems typically employ several processing units. In addition to the central processing unit, or CPU, a special-purpose processor, called the video controller or display controller, is used to control the operation of the display device. Organization of a simple raster system. Here, the frame buffer can be anywhere in the system memory, and the video controller accesses the frame buffer to refresh the screen. In addition to the video controller, more sophisticated raster systems employ other processors as co-processors and accelerators to implement various graphics operations.
- The origin of the coordinate system for identifying screen **positions** is **usually** specified in the lower-left corner. Origin is defined at the lower left screen comer. The screen surface is then represented as the first quadrant of a two-dimensional system, with positive ***x*** values increasing to the right and positive y values increasing from bottom to top. (On some personal computers, the coordinate origin is referenced at the upper left comer of the screen, so the y values are inverted.) **Scan** lines ***are*** then labeled from **y,** at the top of the screen to **0** at the bottom. Along each scan line, screen pixel positions are labeled **from 0** to **x.** In the basic refresh operations of the video controller.
- **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 referenced in Cartesian coordinates. Two registers are used to store the coordinates of the screen pixels.

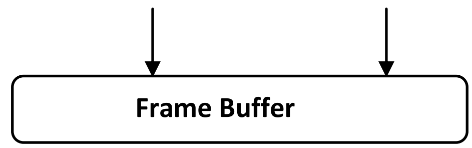
- **Ini**tially, the **x** register is set to **0** and the y register is, set to the value stored in the frame buffer for this pixel position is then retrieved and used to set the intensity of the CRT beam. Then the **x** register is incremented by 1, and the process repeated for the next pixel on the 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 the y register is decremented by 1.



- Architecture **of** a raster-graphics system with a display **processor controller** can retrieve pixel intensities from different memory areas on different refresh cycles. In high quality systems, for example, two frame buffers are often provided so that one buffer can be used for refreshing while the other is being filled with intensity values. Then the two buffers can switch roles. This provides a fast mechanism-for generating real-time animations, since different views of moving objects can be successively loaded in to the refresh buffers. Also, some transformations can be accomplished by the video controller.
- Areas of the screen can be enlarged, reduced, or moved from one location to another during the refresh cycles. In addition, the video controller often contains a lookup table, so that pixel values in the frame buffer are used to access the lookup table instead of controlling the **CRT** beam intensity directly. This provides a fast method for changing screen intensity values. Finally, some systems are designed to allow the video controller to mix the frame-buffer image with an input image from a television camera or other input device.

Horizontal and Vertical Deflection Voltages





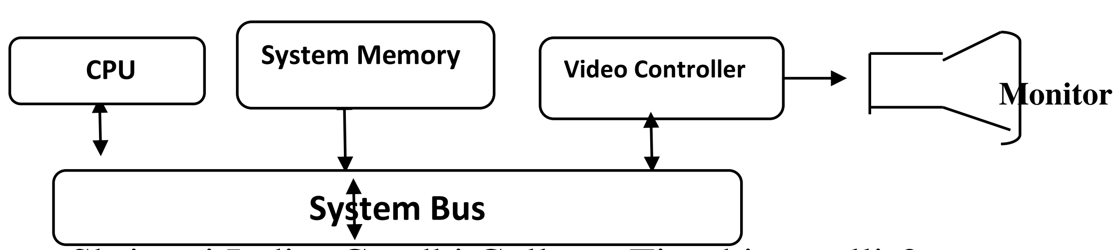
- Raster-Scan **Display** Process one way to **set** up the organization of a raster system containing a separate display processor, sometimes referred to as a graphics controller or a display coprocessor. The purpose of the display processor is to free the CPU from the graphics chores. In addition to the system memory, a separate display processor memory area can **also** be provided. The array size for character grids can vary from about **5** by 7 to 9 by **12** or more for higher-quality displays.
- 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 caIled scan conversion. Graphics commands specifying straight lines and other geometric objects are scan converted **A** character **defined** as a in to a set of discrete intensity points. Scan converting a straight-line segment, for rectangular grid **of pixel** example, means that we have to locate the pixel positions closest to the line path positions and store the intensity for each position in the frame buffer. 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 **5** outlines.

Disadvantages:

The disadvantages of encoding **runs** are that intensity changes are difficult to make and storage requirements actually increase as the length of the runs decreases.

6. **Write short note on Random-Scan Display.**

The organization of a simple random-scan (vector) 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 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.

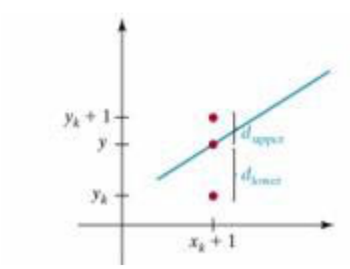


I/O Devices

Architecture of a simple random scan system. 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 **Graphics Monitors** values for their coordinate endpoints, and these input coordinate values are con- **and Workstations** vertex to **x** and y deflection voltages. **A** scene is then drawn one line at a time by positioning the beam to fill in the line between specified endpoints.

<u>10 Marks</u> :

1. **Explain in detail about Bresenham's Line Algorithm.**
   - An accurate, efficient raster line drawing algorithm developed by Bresenham, scan converts lines using only *incremental integer* calculations that can be adapted to display circles and other curves.
   - Keeping in mind the symmetry property of lines, lets derive a more efficient way of drawing a line.
   - Starting from the left end point ($x0$,$y0$) of a given line , we step to each successive column (x position) and plot the pixel whose scan-line y value closest to the line path
   - Assuming we have determined that the pixel at (xk,yk) is to be displayed, we next need to decide which pixel to plot in column xk+1.



- Choices are*(xk +1, yk)* and *(xk+1, yK+1)*

$$d1 = y - yk = m(xk + 1) + b - yk$$

$$d2 = (yk + 1) - y = yk + 1 - m(xk + 1) - b$$

- The difference between these 2 separations is d1-d2 = 2m(xk + 1) – 2 yk + 2b – 1
- A decision parameter *pk* for the *kth* step in the line algorithm can be obtained by rearranging above equation so that it involves only *integer calculations*
- Define $Pk = x (d1\text{-}d2) = 2 \; yxk\text{-}2 \quad xyk + c$

  The sign of *P*k is the same as the sign of *d1-d2*, since $x > 0$.

Parameter c is a constant and has the value *2 y + x(2b-1)* (independent of pixel position)

- If *pixel at yk* is closer to line-path than pixel at *yk +1*

(i.e, if d1 < d2) then *pk* is negative. We plot lower pixel in such a case. Otherwise , upper pixel will be plotted.

- At step *k + 1*, the decision parameter can be evaluated as, *pk+1 = 2 yxk+1 - 2 xyk+1 + c*
- Taking the difference of pk+ 1 and pk we get the following.

pk+1 – pk = 2 y(xk+1- xk)-2 x(yk+1 – yk)

- But, *xk+1 = xk +1*, so that

pk+1 = pk + 2 y - 2 x(yk+1 – yk)

- Where the term *yk+1-yk* is either 0 or 1, depending on the sign of *parameter pk*
- The first parameter *p0* is directly computed

p0 = 2 yxk - 2 xyk + c = 2 yxk – 2 y + x (2b-1)

ν Since (x0,y0) satisfies the line equation , we also have

y0 = y/ x * x0 + b

ν Combining the above 2 equations , we will have

p0 = 2 y – x. The constants 2 y and 2 y-2 x are calculated once for each time to be scan converted. ν So, the arithmetic involves only integer addition and subtraction of 2 Constants.

2. Explain about the Characteristics of Attributes.

The appearance of displayed character is controlled by attributes such as font, size, color and orientation. Attributes can be set both for entire character strings (text) and for individual characters defined as marker symbols

Text Attributes:

The choice of font or type face is set of characters with a particular design style as courier, Helvetica, times roman, and various symbol groups.

The characters in a selected font also be displayed with styles. (solid, dotted, double) in **bold face** in **Italics**, and in **Outline** or shadow styles.

integer code for the text font parameter tf in the function

setTextFont (tf)

Control of text color (or intensity) is managed from an application program with

setTextColourIndex (tc)

Where text color parameter tc specifies an allowable color code.

Text size can be adjusted without changing the width to height ratio of characters with

setCharacterHeight (ch)

Parameter ch is assigned a real value greater than 0 to set the oordinate height of capital letters. The width only of text can be set with function.

setCharacterExpansionFactor (cw)

Where the character width parameter cw is set to a positive real value that scales the body width of character. Spacing between characters is controlled separately with

setCharacterSpacing (cs)

Where the character-spacing parameter cs can he assigned any real value

The orientation for a displayed character string is set according to the direction of the character up vector

setCharacterUpVector (upvect)

Parameter upvect in this function is assigned two values that specify the x and y vector components. For example, with upvect = (1, 1), the direction of the up vector is 45o and text would be displayed .

To arrange character strings vertically or horizontally

setTextPath (tp)

can be assigned the value: right, left, up, or down

Another handy attribute for character strings is alignment. This attribute specifies how text is to be positioned with respect to the $tart coordinates. Alignment attributes are set with

setTextAlignment(h,v)

where parameters h and v control horizontal and vertical alignment. Horizontal alignment is set by assigning h a value of left, center, or right. Vertical alignment is set by assigning v a value of top, cap, half, base or bottom.

A precision specification for text display is given with

setTextPrecision(tpr)

tpr is assigned one of values string, char or stroke.

Marker Attributes:

A marker symbol is a single character that can he displayed in different colors and in different sizes. Marker attributes are implemented by procedures that load the chosen character into the raster at the defined positions with the specified color and size. We select a particular character to be the marker symbol with

setMarkerType(mt)

where marker type parameter mt is set to an integer code. Typical codes for marker type are the integers 1 through 5, specifying, respectively, a dot (.) a vertical cross (+), an asterisk (*), a circle (o), and a diagonal cross (X).

We set the marker size with

setMarkerSizeScaleFactor (ms)

with parameter marker size ms assigned a positive number. This scaling parameter is applied to the nominal size for the particular marker symbol chosen. Values greater than 1 produce character enlargement; values less than 1 reduce the marker size.

Marker color is specified with

setPolymarkerColourIndex (mc)

A selected color code parameter mc is stored in the current attribute list and used to display subsequently specified marker primitives

Bundled Attributes:

A particular set of attributes values for a primitive on each output device is chosen by specifying appropriate table index. Attributes specified in this manner are called bundled attributes.

setIndividualASF(attributeptr, flagptr)

where parameter attributer ptr points to a list of attributes and parameter flagptr points to the corresponding list of aspect source flags. Each aspect source flag can be assigned a value of individual or bundled.

Bundled line Attributes:

Entries in the bundle table for line attributes on a specified workstation are set with the function

setPolylineRepresentation (ws, li, lt, lw, lc)

Parameter ws is the workstation identifier and line index parameter li defines the bundle table position. Parameter lt, lw, tc are then bundled and assigned values to set the line type, line width, and line color specifications for designated table index.

Example:

setPolylineRepresentation (1, 3, 2, 0.5, 1)

setPolylineRepresentation (4, 3, 1, 1, 7)

Bundle area fill Attributes:

Table entries for bundled area-fill attributes are set with

setInteriorRepresentation (ws, fi, fs, pi, fc)

Which defines the attributes list corresponding to fill index fi on workstation ws. Parameter fs, pi and fc are assigned values for the fill style pattern index and fill color.

Bundled Text Attributes:

setTextRepresentation (ws, ti, tf, tp, te, ts, tc)

Bundles values for text font, precision expansion factor size an color in a table position for work station ws that is specified by value assigned to text index parameter ti.

Bundled marker Attributes:

setPolymarkerRepresentation (ws, mi, mt, ms, mc)

That defines marker type marker scale factor marker color for index mi on workstation ws.

3.Elucidate about the Two Dimensional Geometric Transformations.

Changes in orientations, size and shape are accomplished with geometric transformations that alter the coordinate description of objects.

Basic transformation:

* Translation
  > T(tx, ty)
  > Translation distances
* Scale
  > S(sx,sy)
  > Scale factors
* Rotation
  > R( )
  > Rotation angle

Translation:

A translation is applied to an object by representing it along a straight line path from one coordinate location to another adding translation distances, tx, ty to original coordinate position (x , y) to move the point to a new position (x', y') to

$$x' = x + tx, \; y' = y + ty$$

The translation distance point (tx,ty) is called translation vector or shift vector.

Translation equation can be expressed as single matrix equation by using column vectors to represent the coordinate position and the translation vector as

Moving a polygon from one position to another position with the translation vector (-5.5, 3.75)

Scaling:

A scaling transformation alters the size of an object. This operation can be carried out for polygons by multiplying the coordinate values (x, y) to each vertex by scaling factor Sx & Sy to produce the transformed coordinates (x', y')

$$x' = x.Sx \qquad\qquad y' = y.Sy$$

scaling factor Sx scales object in x direction while Sy scales in y direction.
The transformation equation in matrix form

(or)

P' = S. P

Where S is 2 by 2 scaling matrix . Turning a square

(b) with scaling factors sx = 2 and sy = 1.

(a) Into a rectangle

Any positive numeric values are valid for scaling factors sx and sy. Values less than 1 reduce the size of the objects and values greater than 1 produce an enlarged object.
There are two types of Scaling. They are

* **Uniform Scaling**
* **Non Uniform Scaling**

To get uniform scaling it is necessary to assign same value for sx and sy. Unequal values for sx and sy result in a non uniform scaling.

Rotations:

A two-dimensional rotation is applied to an object by repositioning it along a circular path on xy plane. To generate a rotation, specify a rotation angle θ and the position (x_r, y_r) of the rotation point (pivot point) about which the object is to be rotated.

Positive values for the rotation angle define counter clock wise rotation 88about pivot point. Negative value of angle rotate objects in clock wise direction. The transformation can also be described as a rotation about a rotation axis perpendicular to xy plane and passes through pivot point.

Rotation of a point from position (x, y) to position (x', y') through angle θ relative to coordinate origin

The transformation equations for rotation of a point position P when the pivot point is at coordinate origin. In figure r is constant distance of the point positions Φ is the original angular of the point from horizontal and θ is the rotation angle.

The transformed coordinates in terms of angle θ and Φ

$$x' = r\cos(\theta+\Phi) = r\cos\theta \cos\Phi - r\sin\theta\sin\Phi$$

$$y' = r\sin(\theta+\Phi) = r\sin\theta \cos\Phi + r\cos\theta\sin\Phi$$

The original coordinates of the point in polar coordinates

$$x = r\cos\Phi, y = r\sin\Phi$$

the transformation equation for rotating a point at position (x,y) through an angle θ about origin

$$x' = x\cos\theta - y\sin\theta$$
$$y' = x\sin\theta + y\cos\theta$$

Rotation Equation

$$P' = R . P$$

Rotation Matrix

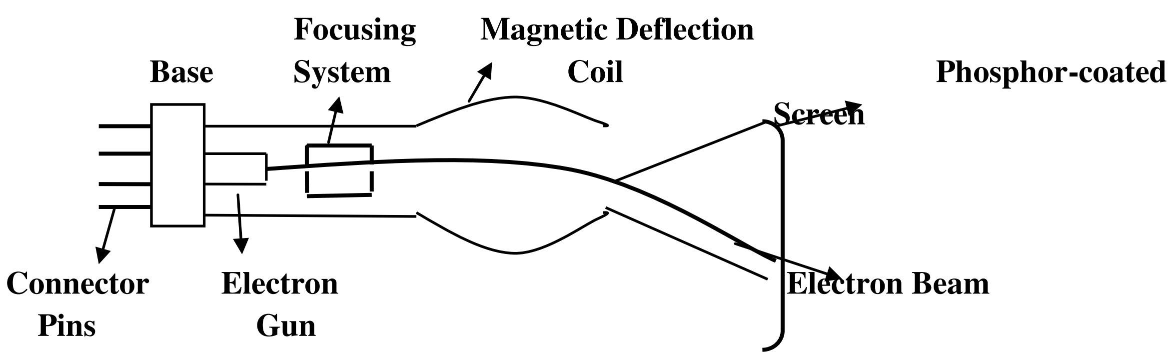
4.Explain in detail about Video Display Devices.

The primary output device in a graphics system is a video monitor. The operation of most video monitors is based on the standard cathode-ray tube (CRT) design, but several other technologies monitors.

Construction:

CRT tube will be covered by cylindrical cathode. The end position has phosphor sealed or coated screen. In phosphor screen having two edges outer & inner edges. Electrons are travel through electron beam. Connector pins, Electron gun, focusing screen and Magnetic deflection coils are used. Vertical & Horizontal plates are fixed in CRT tube.

Magnetic-Deflection CRT

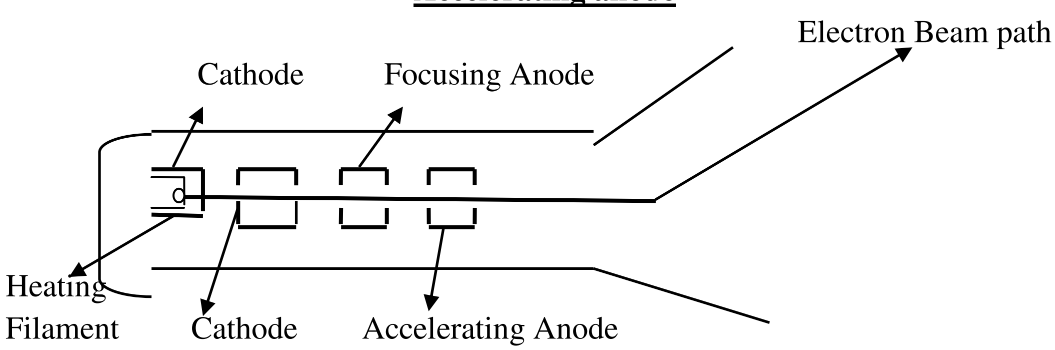


Procedure:

- ✓ 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. Because the light emitted by the phosphor fades very rapidly, some method is needed for maintaining the screen picture.

- ✓ Heat is supplied to the cathode by directing a current through a coil of wire, called the filament, inside the cylindrical cathode structure. In the vacuum inside the CRT envelope, the free, negatively charged electrons are then accelerated toward the phosphor coating by a high positive voltage.
- ✓ A high negative voltage applied to the control grid will shut off the beam by repelling electrons and stopping them from passing through the small hole at the end of the control grid structure. A smaller negative voltage on the control grid simply decreases the number of electrons passing through. Since the amount of light emitted by the phosphor coating depends on the number of electrons striking the screen.

<u>Accelerating anode</u>



- ✓ Focusing is accomplished with either electric or magnetic fields. Electrostatic focusing is commonly used in television and computer graphics monitors. “With electrostatic as the beam moves to the outer edges of the screen, displayed images become blurred”.
- ✓ Two pairs of coils are used, with the coils in each pair 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 ‘opposite sides’ of the neck. The magnetic, field produced by each pair of coils results in a transverse deflection force that is perpendicular both to the direction of the magnetic field and to the direction of travel of the electron beam.
- ✓ 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. When electrostatic deflection is used, two pairs of parallel plates are mounted inside the CRT envelope. One pair of plates is

mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control horizontal deflection.

Refresh CRT:

- "One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same points. This type of display is called a refresh CRT".

Resolution:

- The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution.

Persistent:

- Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity.
- Although some phosphors have persistence greater than 1 second, Graphics monitors are usually constructed with persistence in the range from 10 to 60 microseconds.

Aspect Ratio:

- Another property of video monitors is aspect ratio. This number gives the ratio of vertical points to horizontal points necessary to produce equal length lines in both directions on the screen.

  "X=Vertical points/Horizontal points";
- An aspect ratio of 3/4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.

5.Explain in detail about Flat-Panel Display.

Although most graphics monitors are still constructed with CRTs, other technologies Are emerging that may soon replace CRT monitors. The term Bat-panel display refers to a class of video devices that have reduced volume, weight, and power requirements compared to a CRT. A significant feature of flat-panel displays is that they are thinner than CRTs, and we can hang them on walls or wear them on our wrists. Since we can even write on some flat-panel displays, they will soon be available as pocket notepads. Current uses for flat-panel displays include small **TV** monitors, calculators, pocket video games, laptop computers, armrest viewing of movies on airlines, as advertisement boards in elevators, and as graphics displays in applications requiring rugged, portable monitors.

We can separate flat-panel displays into **two categories**:

- **Emissive displays and**
- **Non Emissive displays.**

Emissive displays:-

The emissive displays (or emitters) are devices that convert electrical energy into light. Plasma panels, thin-film electroluminescent displays, and Light-emitting diodes are examples of emissive displays. Flat CRTs have also been devised, in which electron beams arts accelerated parallel to the screen, then deflected 90' to the screen. But flat CRTs have not proved to be as successful as other emissive devices.

Non Emissive displays:-

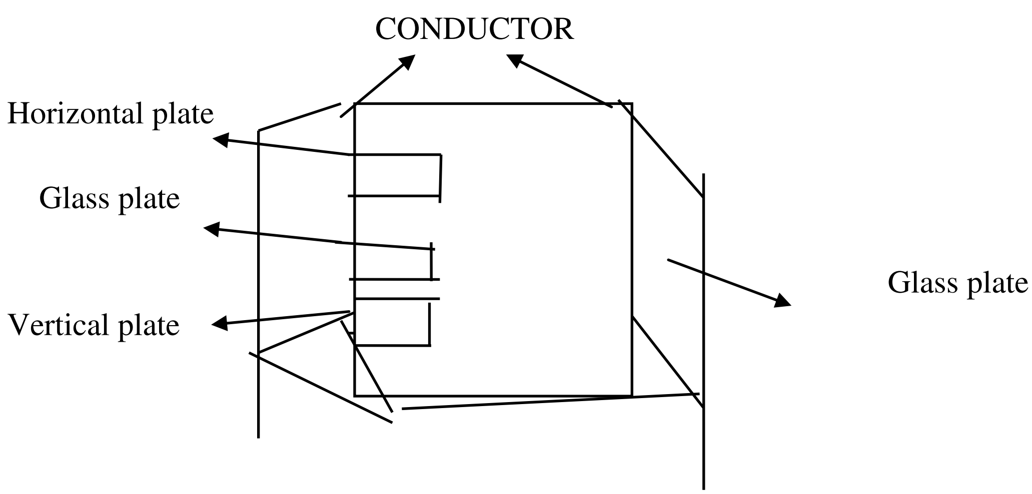
Non Emissive displays (or non emitters) use optical effects to convert sunlight or light from some other source into graphics patterns. The most important example of a non emissive flat-panel display is a liquid-crystal device.

- **Plasma-Panel:**

  Plasma panels, also called gas-discharge displays, are constructed by filling the region between two glass plates with a mixture of gases that usually in **2** dude's neon. A series of vertical conducting ribbons is placed on one glass panel, and a **set** of horizontal ribbons is built into the other glass panel**.** Firing voltages applied to a pair of horizontal and vertical conductors cause the gas at the intersection of the two conductors to break down into glowing plasma of electrons and ions. Picture definition is stored in a refresh buffer, and the firing voltages are applied to refresh the pixel positions (at the intersections of the conductors) 60 times per second. Alternating-methods **are** used to provide faster application of the firing voltages, and thus brighter displays. Separation **between** pixels is provided by the electric field of the conductor shows a high definition plasma panel.

Disadvantage:

Plasma Panels has **been** that they were strictly **monochromatic devices**, but systems have been developed that are now capable of displaying color and grayscale.



- **Thin-Film Electroluminescent Display:**

  - **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 zinc sulfide doped with manganese, instead of a gas. When a high voltage is applied to a pair of crossing elec**trodes,** the phosphor becomes a conductor in the area of the intersection of the two electrodes. Electrical energy is then absorbed by the manganese atoms, which then release the energy as a spot of light similar to the glowing plasma effect in a plasma panel.
  - Electroluminescent displays require more power than plasma panels, and good color and gray scale displays are hard to achieve. **A** third **type** of emissive device is the light-emitting diode **(LED). A** matrix of diodes is arranged to form the pixel positions in the display, and picture definition is stored in a refresh buffer. **As** in xan-line refreshing of a **CRT,** information.
  - ***A*** plasma-panel display with a **resolution** of ***2048*** by 2048 and a screen diagonal of 1.5 meters. Basic design of a thin-film electroluminescent display device is read from the refresh buffer and converted to voltage levels that are applied to small systems.

- **Liquid-Crystal Display:**

  - These Non-Emissive devices produce a picture by passing polarized light from the surroundings or from an internal light **s** through a liquid-crystal material that can be aligned to either block or transmit the light , such as calculators and portable laptop computers.
  - The term ***liquid crystal*** refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid. Flat-panel displays commonly use nematic (threadlike) liquid-crystal compounds that tend to keep the long axes of the rod-shaped molecules aligned. **A** flat-panel display can then be constructed with a nematic liquid crystal. Two glass plates, each containing a light polarizer at right angles to the-other plate, sandwich the liquid-crystal material. Rows of horizontal transparent conductors are built into one glass plate, and columns of vertical conductors are put into the other plate. The intersection **of** two conductors defines a pixel position.
  - Normally, the molecules are aligned as shown in the "on state". Polarized light passing through the material is twisted so that it will pass through the opposite polarizer. The light is then reflected back to the viewer. To **turn** off the pixel, we apply a voltage to the two intersecting conductors to align the molecules **so** that the light ***is*** not twisted. This type of flat-panel device is refferred to as a

passive-matrix LCD. Picture definitions are stored in a refresh buffer, and the screen is refreshed at the rate of 60 frames per second, as in the emissive devices.

- A hand calculator with an Back lighting is also commonly applied using solid-state electronic devices, so that the system is not completely dependent on outside light be displayed by using different materials or dyes and by placing a triad of color pixel set each &screen location. Another method for constructing LCD's is to place a transistor at each pixel location, using thin-film transistor technology. The transistors are used to control the voltage at pixel locations and to prevent charge from gradually leaking out of the liquid-crystal cells. These devices are called active-matrix displays.

6.Explain in detail about Input Devices.

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

Keyboards:

a) An alpha numeric keyboard on a graphics system is used primarily as a device for entering text strings. The keyboard is an efficient device for inputting such non graphic data as picture labels associated with a graphics display. Keyboards can **also** be provided with features to facilitate entry of screen coordinates, menu selections, or graphics functions. Cursor-control keys and function keys are common features on general purpose keyboards.

b) Function keys allow users to enter frequently used operations in a single keystroke, and cursor-control keys can be **used** to select displayed objects or coordinate positions by positioning the screen cursor. Other types of cursor-positioning devices, such as a trackball or joystick, are included on some keyboards. Additionally, a numeric keypad is, often included on the keyboard for fast entry of numeric data.

c) 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 an example of a button **box** and a set of input dials. 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) 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 directly **designed** keyboard with removable palm **rests.** Another method for detecting mouse motion is with an optical sensor. For these systems, the mouse is moved over a special mouse pad that has a rid of horizontal and vertical lines. The optical sensor detects movement across the lines in the grid. **Since** a mouse **can** be picked up and put down at another position without range in cursor movement, it is **used** for **making** relative change in the position of the screen cursor. One, two, or three buttons usually included on the top of the mouse for signaling the execution of some operation, **such as recording** position or invoking a function. Mast general-purpose graphics systems now include a mouse and a keyboard as the major input devices.

b) Additional devices **can** be included in the basic mouse design to increase the number of allowable input parameters. **The *2*** mouse features three buttons, a mouse ball underneath, a thumbwheel on the side, and a track ball on top three buttons, a thumbwheel on the side, a trackball on the top, and a standard mouse ball underneath. This design provides **six** degrees of freedom to select **Input Devices** spatial positions, rotations, and other parameters up an object, rotate it, and move it in any direction, or **we** can navigate our viewing position and orientation through a three dimensional **scene.** Applications of the Z mouse include virtual reality, CAD, and animation.

Trackball and Space ball:

As the name implies, a trackball is a ball that can be rotated with the fingers or palm of the hand, as to produce screen-cursor movement. Potentiometers, attached to the ball, measure the amount and direction of rotation. Trackballs are often mounted on keyboards or **other** devices such as the Z mouse. While a trackball is a two-dimensional positioning device, a space ball provides six degrees of freedom. Unlike the trackball, a space ball does not actually move. Strain gauges measure the amount of pressure applied to the space ball to provide input for spatial positioning and orientation as the ball is pushed or pulled in various directions. Space balls are used for three-dimensional positioning and selection operations in virtual-reality systems, modeling, animation, CAD, and other applications.

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; Some joysticks are mounted on a keyboard; The distance that the stick is moved in any direction from its center position corresponds to screen-cursor movement in that direction. Potentiometers mounted at the base of the joystick measure the amount of movement, and springs **return** the stick to the center position when it is released. One or more buttons can be programmed to act as input switches to signal certain actions once a screen position has been selected. In another type of movable joystick, the stick is used to activate switches that cause the screen cursor to move at a constant rate in the direction selected. Eight switches, arranged in a circle, are sometimes provided, so that the stick **can** select any one of eight directions for cursor movement. Pressure sensitive joysticks, also called isometric joysticks, have a non movable stick. **Pressure** on the stick is measured with strain gauges and converted to movement of the cursor in the direction specified.

Data Glove:

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. The transmitting and receiving antennas can each be structured as a set of three mutually perpendicular coils, forming a three-dimensional Cartesian coordinate System. Input from the glove can be used to position or manipulate objects in a virtual scene. A two-dimensional proportion 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-dimensional or a three-dimensional space. Typically, a digitizer is used to **scan** over a drawing or object and to input a set of discrete coordinate positions, which can be joined with straight-Line segments to approximate the curve or surface shapes. One **type** of digitizer ***is*** the graphics tablet (also referred to as a 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 pencil-shaped device that is pointed.

A virtual-reality, displayed on a two-dimensional video monitor, with input from a data glove a d a space ball of desktop and floor-model tablets, using **2,4,** or **16** buttons. This allows an artist to produce different brush strokes with different pressures on the tablet surface. Tablet size varies from **12** by **12** inches for desktop models to 44 by 60 inches or larger for floor models. 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. Electromagnetic pulses are generated in sequence along the wires, and an electric signal is induced in a wire coil in an activated or hand cursor to record a tablet position. Depending on the technology, 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 word positions.

One electromagnetic transmission method is similar to that used in the data glove: A coupling between the transmitter and receiver is used to compute the location of a stylus as it moves over the surface of an object. As the points are selected on a non metallic object, a wire frame outline of the surface is displayed on the computer screen. Once the surface outline is constructed, it can be shaded with lighting effects to produce a realistic display of the object. Resolution of this system is 0.8 mm to 0.08 mm**,** depending on the model.

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. The gradations of grey scale or color are then recorded and stored in an array. Once we have the internal representation of a picture, we can apply transformations to rotate, scale, or crop the picture to a particular screen area. We can also apply various image-processing methods to modify the array representation of the picture. For scanned text input, various editing operations can be performed on the stored documents. Some scanners are able to scan either graphical representations or text, and they come in a variety of sizes and capabilities.

Touch Panels:

As the name implies, 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. Some systems, are designed with touch screens. Other systems can be adapted for touch input by fitting a transparent device with a touch sensing mechanism over the video monitor screen. 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.

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 **A** light pen activated with a button switch operations or to enter data. These systems operate by matching an input are predefined dictionary of words and phrase. A dictionary is set up for a particular operator by having, the operator speak the command words to be used into the system. Each word is spoke Several times, and the system analyzes the word and establishes a frequency pattern for that word in the dictionary along with the corresponding function to be performed. Later, when a voice command is given, the system searches the dictionary for a frequency-pattern match. Voice input is typically spoken into a microphone mounted on a headset. The microphone is designed to minimize input of other background sounds. If a different operator is to use the system, the dictionary must be re-established with that operator's voice patterns. Voice systems have some advantage over other input devices, since the attention of the operator does not have to be switched from one device to another to enter a command.

UNIT - II

1. **What is the need of homogeneous coordinates?**

To perform more than one transformation at a time, use homogeneous coordinates or matrixes. They reduce unwanted calculations intermediate steps saves time and memory and produce a sequence of transformations.

2. **Define Projection.**

The process of displaying 3D into a 2D display unit is known as projection. The projection transforms 3D objects into a 2D projection plane.

3. **What are the types of Basic Transformations?**

1.Translation

2.Scaling

3.Rotation

4. **What is translation?**

Translation is the process of changing the position of an object in a straight-line path from one coordinate location to another. Every point (x , y) in the object must undergo a displacement to x|,y|). the transformation is: x| = x + tx y| = y+ty

5. **What is scaling?**

The scaling transformations changes the shape of an object and can be carried out by multiplying each vertex (x,y) by scaling factor Sx,Sy where Sx is the scaling factor of x and Sy is the scaling factor of y.

6. **What is a rotation?**

A two-dimensional rotation is applied to an object by repositioning it along a circular path on xy plane. To generate a rotation, specify a rotation angle θ and the position (x_r, y_r) of the rotation point (pivot point) about which the object is to be rotated.

7. **What is shearing?**

The shearing transformation actually slants the object along the X direction or the Y direction as required.ie; this transformation slants the shape of an object along a required plane.

8..**What is reflection?**

The reflection is actually the transformation that produces a mirror image of an object. For this use some angles and lines of reflection.

9..Define dimensional viewing .

Two dimensional viewing The viewing pipeline A world coordinate area selected for display is called a window. An area on a display device to which a window is mapped is called a view port. The window defines what is to be viewed the view port defines where it is to be displayed. The mapping of a part of a world coordinate scene to device coordinate is referred to as viewing transformation. The two dimensional viewing transformation is referred to as window to view port transformation of windowing transformation.

10.Explain about Window to Viewport transformation.

The window defined in world coordinates is first transformed into the normalized device coordinates. The normalized window is then transformed into the viewport coordinate. The window to viewport coordinate transformation is known as workstation transformation

.

11.what are steps in windows translations?

1. The object together with its window is translated until the lower left corner of the window is at the orgin.

2. Object and window are scaled until the window has the dimensions of the viewport.

3. Translate the viewport to its correct position on the screen.

12.What is 2D Clipping?

The clipping algorithm determines which points, lines or portions of lines lie within the clipping window. These points, lines or portions of lines are retained for display. All other are discarded. Possible clipping are

1. Point clipping
2. Line clipping
3. Area clipping
4. Curve Clipping
5. Text Clipping

13.Define Point Clipping:

The points are said to be interior to the clipping if XWmin <= X <=XW max

YWmin <= Y <=YW maxThe equal sign indicates that points on the window boundary are included within the window.

14.Define Line Clipping:

- The lines are said to be interior to the clipping window, if the two end points of the lines are interior to the window.
- If the lines are completely right of, completely to the left of, completely above, or completely below the window, then it is discarded.

15.Explain about Sutherland and cohen subdivision line clipping algorithm.

It is developed by Dan Cohen and Ivan Sutharland. To speed up the processing this algorithm performs initial tests that reduces the number of intersections that must be calculated,given a line segment, repeatedly:

1. check for trival acceptance both
2. check for trivial rejection both endpoints of the same side of clip rectangle
3. both endpoints outside clip rectangle

16.Define Mid point subdivision algorithm

If the line partially visible then it is subdivided in two equal parts. The visibility tests are then applied to each half. This subdivision process is repeated until we get completely visible and completely invisible line segments.

Mid point sub division algorithm

1. Read two end points of the line P1(x1,x2), P2(x2,y2)

2. Read two corners (left top and right bottom) of the window, say (Wx1,Wy1 and Wx2, Wy2)

17. Define Liang-Barsky line clipping algorithm

The cohen Sutherland clip algorithm requires the large no of intesection calculations.here this is reduced. The update parameter requires only one division and windows intersection lines are computed only once.

18.Define Nicholl-lee Nicholl line clipping.

It Creates more regions around the clip window. It avoids multiple clipping of an individual line segment. Compare with the previous algorithms it perform few comparisons and divisions . It is applied only 2 dimensional clipping.

5 MARKS

1. **Write a Homogeneous Coordinates in 2 Dimensions**

Scaling and rotations are both handled using matrix multiplication, which can be combined as we will see shortly. The translations cause a difficulty, however, since they use addition instead of multiplication.

We want to be able to treat all 3 transformations (translation, scaling, rotation) in the same way - as multiplications.

The solution is to give each point a third coordinate (X, Y, W), which will allow translations to be handled as a multiplication also.

(Note that we are not really moving into the third dimension yet. The third coordinate is being added to the mathematics solely in order to combine the addition and multiplication of 2-D coordinates.)

Two triples (X,Y,W) and (X',Y',W') represent the same point if they are multiples of each other e.g. (1,2,3) and (2,4,6).

At least one of the three coordinates must be nonzero.

If W is 0 then the point is at infinity. This situation will rarely occur in practice in computer graphics.

If W is nonzero we can divide the triple by W to get the cartesian coordinates of X and Y which will be identical for triples representing the same point (X/W, Y/W, 1). This step can be considered as mapping the point from 3-D space onto the plane W=1.

Conversely, if the 2-D cartesian coordinates of a point are known as (X, Y), then the homogenous coordinates can be given as (X, Y, 1)

Translation of 2D Homogenous Coordinates

point (X,Y) is to be translated by amount Dx and Dy to location (X',Y')

X' = Dx + X
Y' = Dy + Y

or P' = T * P where

$$P' = \begin{bmatrix} X' \\ Y' \\ 1 \end{bmatrix}$$

$$T = \begin{bmatrix} 1 & 0 & Dx \\ 0 & 1 & Dy \\ 0 & 0 & 1 \end{bmatrix} = T(Dx,Dy)$$

$$P = \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

Hey Look! Translation is now a multiplication instead of an addition!**Scaling of 2D Homogenous Coordinates**

P' = S * P where

_ _

$$P' = \begin{bmatrix} X' \\ Y' \\ 1 \end{bmatrix}$$

$$S = \begin{bmatrix} Sx & 0 & 0 \\ 0 & Sy & 0 \\ 0 & 0 & 1 \end{bmatrix} = S(Sx,Sy)$$

$$P = \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

Rotation of 2D Homogenous Coordinates

P' = R * P where

$$P' = \begin{bmatrix} X' \\ Y' \\ 1 \end{bmatrix}$$

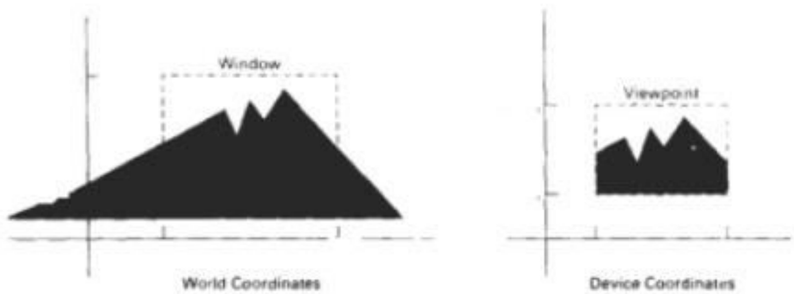
$$R = \begin{bmatrix} \cos(theta) & -\sin(theta) & 0 \\ \sin(theta) & \cos(theta) & 0 \\ 0 & 0 & 1 \end{bmatrix} = R(theta)$$

$$P = \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}$$

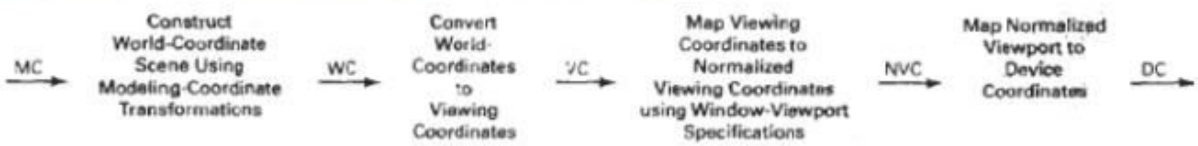
2.Explain the two dimensional viewing concepts in brief.

A world coordinate area selected for display is called a window. An area on a display device to which a window is mapped is called a view port. The window defines what is to be viewed the view port defines where it is to be displayed. The mapping of a part of a world coordinate scene to device coordinate is referred to as viewing transformation. The two dimensional viewing transformation is referred to as window to view port transformation of windowing transformation.

A viewing transformation using standard rectangles for the window and viewport

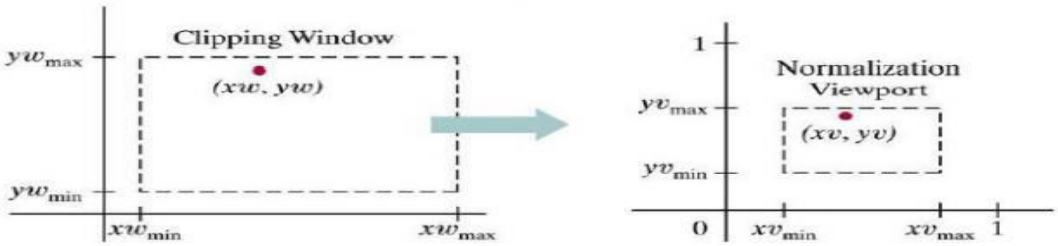


The two dimensional viewing transformation pipeline



The viewing transformation in several steps, as indicated in Fig. First, we construct the scene in world coordinates using the output primitives. Next to obtain a particular orientation for the window, we can set up a two-dimensional viewing-coordinate system in the world coordinate plane, and define a window in the viewing-coordinate system. The viewing- coordinate reference frame is used to provide a method for setting up arbitrary orientations for rectangular windows. Once the viewing reference frame is established, we can transform descriptions in world coordinates to viewing coordinates. We then define a viewport in normalized coordinates (in the range from 0 to 1) and map the viewing-coordinate description of the scene to normalized coordinates.At the final step all parts of the picture that lie outside the viewport are clipped, and the contents of the viewport are transferred to device coordinates. By changing the position of the viewport, we can view objects at different positions on the display area of an output device.

Window to view port coordinate transformation:



A point at position (xw,yw) in a designated window is mapped to viewport coordinates (xv,yv) so that relative positions in the two areas are the same. The figure illustrates the window to view port mapping. A point at position (xw,yw) in the window is mapped into position (xv,yv) in the associated view port. To maintain the same relative placement in view port as in window The conversion is performed with the following sequence of transformations.

3. How selected parts of scene is mapped to different video monitors?Explain.

Window to Viewport transformation

The window defined in world coordinates is first transformed into the normalized device coordinates. The normalized window is then transformed into the viewport coordinate. The window to viewport coordinate transformation is known as workstation transformation.

The object together with its window is translated until the lower left corner of the window is at the orgin. Object and window are scaled until the window has the dimensions of the viewport.Translate the viewport to its correct position on the screen.The relation of the window and viewport display is expressed as XV-XVmin XW-XWmin

-------------- = ----------------

XVmax-XVmin XWmax-XWmin

YV-Yvmin YW-YWmin

------------- = ----------------

YVmax-YVmin YWmax-YWmin

XV=XVmin + (XW-XWwmin)Sx

YV=YVmin + (YW-YWmin)Sy

XVmax-XVmin

Sx= --------------------

XWmax-Xwmin

YVmax-YVmin

Sy= --------------------

YWmax-YWmin

4.Write notes on 2D Clipping in brief.

2D Clipping

The procedure that identifies the portion of a picture that are either inside or outside of a specified regin of space is referred to as clipping. The regin against which an object is to be clipped is called a clip window or clipping window. The clipping algorithm determines which points, lines or portions of lines lie within the clipping window. These points, lines or portions of lines are retained for display. All other are discarded. Possible clipping are Point clipping, Line clipping, Area clipping, Curve Clipping, Text Clipping.

Point Clipping: The points are said to be interior to the clipping if XWmin <= X <=XW max, YWmin <= Y <=YW max

The equal sign indicates that points on the window boundary are included within the window.

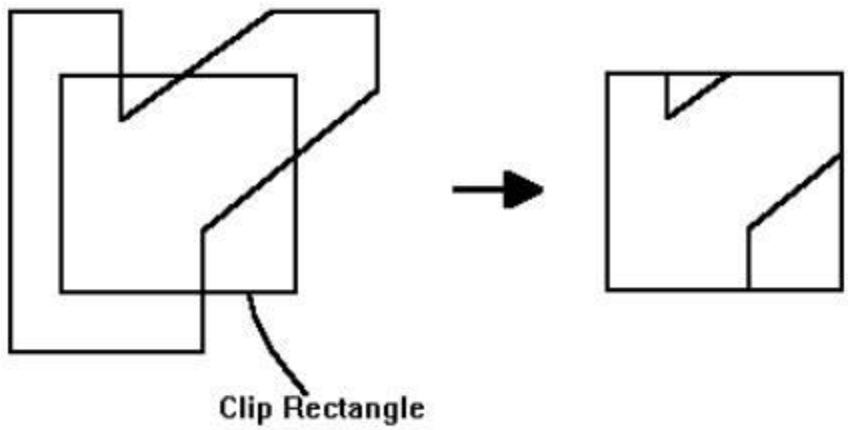
Line Clipping: The lines are said to be interior to the clipping window, if the two end points of the lines are interior to the window. If the lines are completely right of, completely to the left of, completely above, or completely below the window, then it is discarded. Both end points of the line are exterior to the window, then the line is partially inside and partially outside the window.The lines which across one or more clipping boundaries requires calculation of multiple intersection points to decide the visible portion of them.To minimize the intersection calculation and increase the efficiency of the clipping algorithm, initially completely visible and invisible lines are identified and then intersection points are calculated for remaining lines.There are many clipping algorithms. They are **1.Sutherland and cohen subdivision line clipping algorithm, 2. Mid point subdivision algorithm, 3. Liang-Barsky line clipping algorithm, 4. Nicholl-lee Nicholl line clipping,**

Line clipping using non rectangular clip window

Circles and other curved boundaries clipped regions are possible, but less commonly used. Clipping algorithm for those curve are slower. Lines clipped against the bounding rectangle of the curved clipping region. Lines outside the region is completely discarded. End points of the line with circle center distance is calculated . If the squre of the 2 points less than or equal to the radious then save the line else calculate the intersection point of the line.

Polygon clipping: Splitting the concave polygon

It uses the vector method , that calculate the edge vector cross products in a counter clock wise order and note the sign of the z component of the cross products. If any z component turns out to be negative, the polygon is concave and we can split it along the line of the first edge vector in the cross product pair.The following example illustrates a simple case of polygon clipping.



5. Explain the WEILER –Atherton Algorithm.

Instead of proceding around the polygon edges as vertices are processed, we sometime wants to follow the window boundaries.For clockwise processing of polygon vertices, we use the following rules.

- For an outside to inside pair of vertices, follow the polygon boundary.
- For an inside to outside pair of vertices, follow a window boundary in a clockwise direction.

Curve Clipping

It involves non linear equations. The boundary rectangle is used to test for overlap with a rectangular clipwindow. If the boundary rectangle for the object is completely inside the window , then save the object (or) discard the object.If it fails we can use the coordinate extends of individual quadrants and then octants for preliminary testing before calculating curve window intersection.

Text Clipping

The simplest method for processing character strings relative to a window boundary is to use the all or none string clipping strategy. If all the string is inside then accept it else omit it.We discard only those character that are not completely inside the window. Here the boundary limits of individual characters are compared to the window.

Exterior clipping

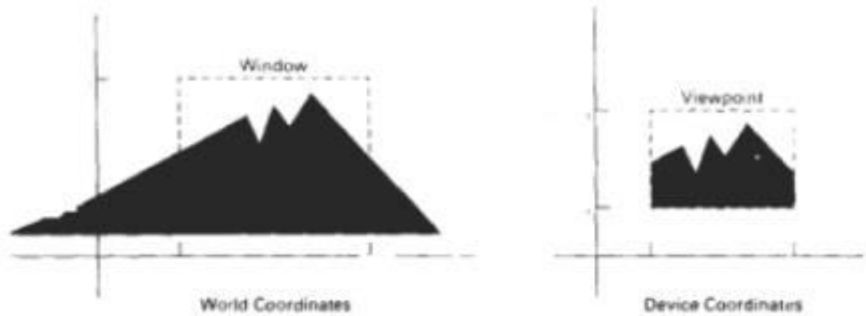
The picture part to be saved are those that are outside the region. This is referred to as exterior clipping. An application of exterior clipping is in multiple window systems. Objects within a window are clipped to the interior of that window. When other higher priority windows overlap these objects , the ojects are also clipped to the exterior of the overlapping window.

10 Marks

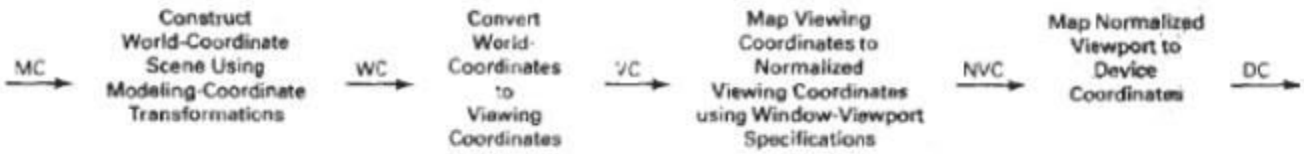
1.Discuss the window and viewport in detail.

Two dimensional viewing The viewing pipeline A world coordinate area selected for display is called a window. An area on a display device to which a window is mapped is called a view port. The window defines what is to be viewed the view port defines where it is to be displayed. The mapping of a part of a world coordinate scene to device coordinate is referred to as viewing transformation. The two dimensional viewing transformation is referred to as window to view port transformation of windowing transformation.

A viewing transformation using standard rectangles for the window and viewport



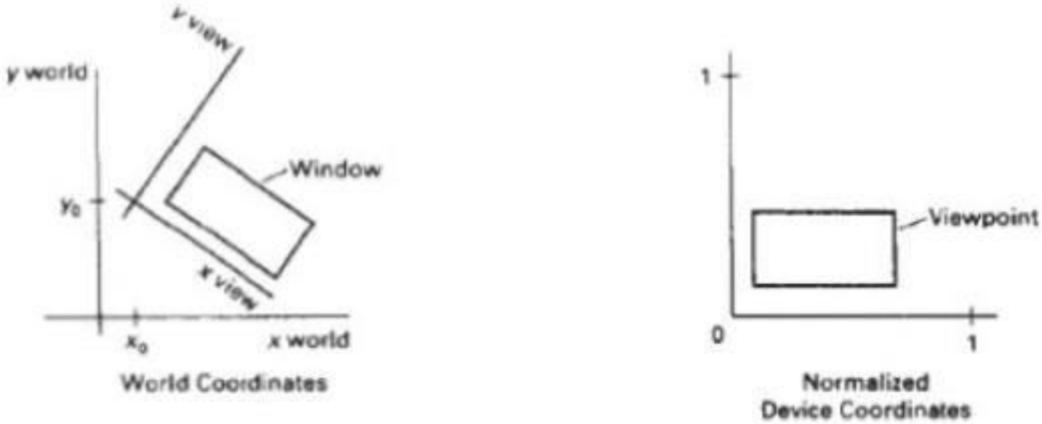
The two dimensional viewing transformation pipeline



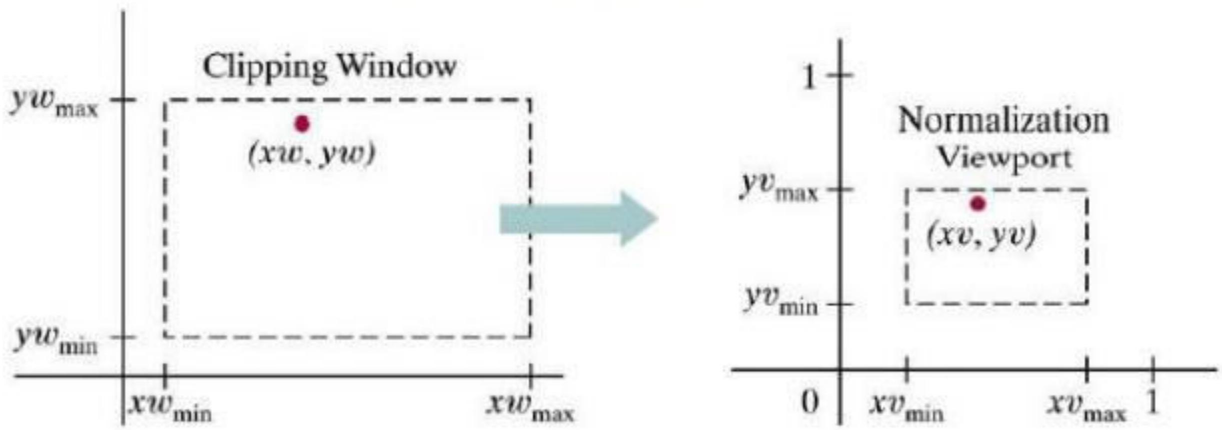
The viewing transformation in several steps, as indicated in Fig. First, we construct the scene in world coordinates using the output primitives. Next to obtain a particular orientation for the window, we can set up a two-dimensional viewing-coordinate system in the world coordinate plane, and define a window in the viewing-coordinate system. The viewing- coordinate reference frame is used to provide a method for setting up arbitrary orientations for rectangular windows.

Once the viewing reference frame is established, we can transform descriptions in world coordinates to viewing coordinates. We then define a viewport in normalized coordinates (in the range from 0 to 1) and map the viewing-coordinate description of the scene to normalized coordinates.

At the final step all parts of the picture that lie outside the viewport are clipped, and the contents of the viewport are transferred to device coordinates. By changing the position of the viewport, we can view objects at different positions on the display area of an output device.



Window to view port coordinate transformation:



A point at position (xw,yw) in a designated window is mapped to viewport coordinates (xv,yv) so that relative positions in the two areas are the same. The figure illustrates the window to view port mapping. A point at position (xw,yw) in the window is mapped into position (xv,yv) in the associated view port. To maintain the same relative placement in view port as in window The conversion is performed with the following sequence of transformations.

Perform a scaling transformation using point position of (xw min, yw min) that scales the window area to the size of view port. Translate the scaled window area to the position of view port. Relative proportions of objects are maintained if scaling factor are the same(Sx=Sy). Otherwise world objects will be stretched or contracted in either the x or y direction when displayed on output device. For normalized coordinates, object descriptions are mapped to various display devices. Any number of output devices can be open in particular application and another window view port transformation can be performed for each open output device. This mapping called the work station transformation is accomplished by selecting a window area in normalized apace and a view port are in coordinates of display device.

2.Explain the Sutherland and cohen subdivision line clipping algorithm.

Line Clipping: The lines are said to be interior to the clipping window, if the two end points of the lines are interior to the window. If the lines are completely right of, completely to the left of, completely above, or completely below the window, then it is discarded. Both end points of the line are exterior to the window, then the line is partially inside and partially outside the window.The lines which across one or more clipping boundaries requires calculation of multiple intersection points to decide the visible portion of them.To minimize the intersection calculation and increase the efficiency of the clipping algorithm, initially completely visible and invisible lines are identified and then intersection points are calculated for remaining lines.There are many clipping algorithms.

Sutherland and cohen subdivision line clipping algorithm

It is developed by Dan Cohen and Ivan Sutharland. To speed up the processing this algorithm performs initial tests that reduces the number of intersections that must be calculated.Check for trival acceptance both.Check for trivial rejection both endpoints of the same side of clip rectangle 3. both endpoints outside clip rectangle. Divide segment in two where one part can be trivially rejected.Clip rectangle extended into a plane divided into 9 regions . Each region is defined by a unique 4-bit string. left bit = 1: above top edge (Y > Ymax) 2nd bit = 1: below bottom edge (Y < Ymin) 3rd bit = 1: right of right edge (X > Xmax) right bit = 1: left of left edge (X < Xmin) left bit = sign bit of (Ymax - Y) 2nd bit = sign bit of (Y - Ymin) 3rd bit = sign bit of (Xmax - X) right bit = sign bit of (X - Xmin)(The sign bit being the most significant bit in the binary representation of the value. This bit is '1' if the number is negative, and '0' if the number is positive.)The frame buffer itself, in the center, has code

0000. 1001 | 1000 | 1010

0001 | 0000 | 0010

0101 | 0100 | 0110 For each line segment:

1. each end point is given the 4-bit code of its region

2. repeat until acceptance or rejection

1. if both codes are 0000 -> trivial acceptance

2. if logical AND of codes is not 0000 -> trivial rejection

3. divide line into 2 segments using edge of clip rectangle

1. find an endpoint with code not equal to 0000

2. lines that cannot be identified as completely inside or outside are checked for the intersection with two boundaries.

3. break the line segment into 2 line segments at the crossed edge

4. forget about the new line segment lying completely outside the clip rectangle

5. draw the line segment which lies within the boundary regin.

3.Discuss the polygon clipping algorithm in detail.

Polygon clipping:

It uses the vector method , that calculate the edge vector cross products in a counter clock wise order and note the sign of the z component of the cross products. If any z component turns out to be negative, the polygon is concave and we can split it along the line of the first edge vector in the cross product pair.

Sutherland – Hodgeman polygon Clipping Algorithm

1. Read the coordinates of all vertices of the polygon.

2. Read the coordinates of the clipping window.

3. Consider the left edge of the window.

4. Compare the vertices of each edge of the polygon, Individually with the clipping plane.

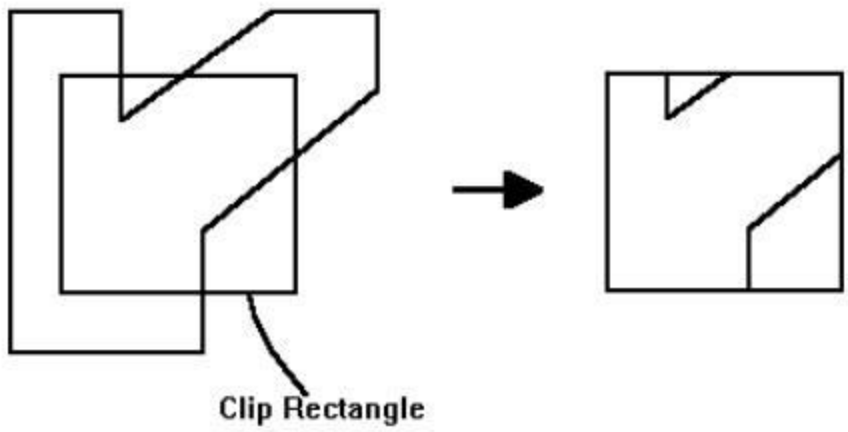
5. Save the resulting intersections and vertices in the new list of vertices according to four possible relationships between the edge and the clipping boundary discussed earlier.

6. Repeats the steps 4 and 5 for remaining edges of the clipping window. Each time the resultant vertices is successively passed the next edge of the clipping window.

7. Stop.

The Sutherland –Hodgeman polygon clipping algorithm clips convex polygons correctly, But in case of concave polygons clipped polygon may be displayed with extraneous lines. It can be solved by separating concave polygon into two or more convex polygons and processing each convex polygons separately.

The following example illustrates a simple case of polygon clipping.



4. Explain the Clipping in detail.

It involves non linear equations. The boundary rectangle is used to test for overlap with a rectangular clipwindow. If the boundary rectangle for the object is completely inside the window , then save the object (or) discard the object.If it fails we can use the coordinate extends of individual quadrants and then octants for preliminary testing before calculating curve window intersection.

Text Clipping: The simplest method for processing character strings relative to a window boundary is to use the all or none string clipping strategy. If all the string is inside then accept it else omit it.We discard only those character that are not completely inside the window. Here the boundary limits of individual characters are compared to the window.

Exterior clipping:

The picture part to be saved are those that are outside the region. This is referred to as exterior clipping. An application of exterior clipping is in multiple window systems.Objects within a window are clipped to the interior of that window. When other higher priority windows overlap these objects , the ojects are also clipped to the exterior of the overlapping window.

UNIT III

1. **What are the Structure Concepts?**

Graphics hardware has in recent years become increa singly programmable, and its programming APIs use the stream processor model to expose massive parallelization to the programmer.Unfortunately, the inherent restrictions of the stream processor model, used by the GPU in order to maintain high performance, often pose a problem in porting CPU algorithms for both video and volume processing to graphics hardware. Serial data dependencies which accelerate CPU processing are counterproductive for the data-parallel GPU.

2. **What are the editing Structures?**

It enables you to include vector graphics in web pages, following the Scalable Vector Graphics (SVG) specification. The goal is not create all SVG elements and attributes, but to implement a subset of the language that is sufficient for the drawings that scientific authors include in their documents. It handles SVG elements as tructured components, in the same way as HTML elements. Therefore, we can manipulate SVG graphics in the structure view as you manipulate other parts of HTML documents. All editing commands provided by Amaya for handling text are also available for handling graphics.

3. **Define Basic Modeling Concepts.**

In 3D computer graphics, 3D modeling (or three-dimensional modeling) is the process of developing a mathematical representation of any *surface* of an object (either inanimate or living) in three dimensions via specialized software. The product is called a 3D model. Someone who works with 3D models may be referred to as a 3D artist. It can be displayed as a two-dimensional image through a process called *3D rendering* or used in a computer simulation of physical phenomena. The model can also be physically created using 3D printing devicesModels may be created automatically or manually. The manual modeling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting.

4. **Define Hierarchical modelling**

It is a statistical model written in multiple levels (hierarchical form) that estimates the parameters of the posterior distribution using the Bayesian method.[1] The sub-models combine to form the hierarchical model, and Bayes' theorem is used to integrate them with the observed data and account for all the uncertainty that is present. The result of this integration is the posterior distribution, also known as the updated probability estimate, as additional evidence on the prior distribution is acquired.

5. **Define Stroke Devices.**

A variety of computer graphic techniques have been used to display video game content throughout the history of video games. The predominance of individual techniques have evolved over time, primarily due to hardware advances and restrictions such as the processing power of central or graphics processing units.

6.Define Input Function.

In computing, an **input device** is a piece of computer hardware equipment used to provide data and control signals to an information processing system such as a computer or information appliance. Examples of input devices include keyboards, mouse, scanners, digital cameras and joysticks. Input devices can be categorized based on: modality o f input (e.g. mechanical motion, audio, degrees of freedom involved (e.g. two-dimensional traditional mice, or three-dimensional navigators designed for CAD applications)

7. Define Grid.

In computer graphics, a **raster graphics** or **bitmap** image is a dot matrix data structure, representing a generally rectangular grid of pixels, or points of color, viewable via a monitor, paper, or other display medium. Raster images are stored in image files with varying formats. A bitmap, a single-bit raster,[2] corresponds bit-for-bit with an image displayed on a screen, generally in the same format used for storage in the display's video memory, or maybe as a device-independent bitmap. A raster is technically characterized by the width and height of the image in pixels and by the number of bits per pixel (or color depth, which determines the number of colors it can represent).

8.Define Constraints.

Joint constraints are rotational constraints on the joints of an artificial bone system. They are used in an inverse kinematics chain, for such things as 3D animation or robotics. Joint constraints can be implemented in a number of ways, but the most common method is to limit rotation about the X, Y and Z axis independently. An elbow, for instance, could be represented by limiting rotation on Y and Z axis to 0 degrees, and constraining the X-axis rotation to 130 degrees.

9.Define Gravity Field

This visualization of a gravity model was created with data from NASA's Gravity Recovery and Climate Experiment (GRACE) and shows variations in Earth's gravity field. Gravity is determined by mass. Earth's mass is not distributed equally, and it also changes over time. The colors in this image represent the gravity anomalies measured by GRACE. One can define standard gravity as the value of gravity for a perfectly smooth 'idealized' Earth, and the gravity 'anomaly' is a measure of how actual gravity deviates from this standard. Red shows the areas where gravity is stronger than the smooth, standard value, and blue reveals areas where gravity is weaker.

5 Marks :-

1. Explain about Replacing Structure Elements.

The Tags panel allows you to view and edit tags in the logical structure tree, or tags tree, of a PDF. In the Tags panel, tags appear in a hierarchical order that indicates the reading sequence of the document. The first item in this structure is the Tags root. All other items are tags and are children of the Tags root. Tags use coded element types that appear in angle brackets (< >). Each element, including structural elements such as sections and articles, appears in the logical structure order by type, followed by a title and the element's content or a description of the content. Structural elements are typically listed as containers (parent tags). They include several smaller elements (child tags) within them. Though you can correct most tagging issues by using the Reading Order tool, you must use the Tags panel to address detailed tagging of tables and substructure items, such as paragraphs, lists, and sections that require multiple languages. Add tags manually to a document in the Tags panel only as a last resort. First consider using the Add Tags To Document command.

2. Explain in detail about pick devices

1. INPUT DEVICES Input devices are things we use to put information into a computer. An input device is any hardware device that sends data to the computer, without any input devices, a computer would only be a display device and not allow users to interact with it, much like a TV. For example, a keyboard is an input device. Input devices other than the keyboard are sometimes called alternate input devices. Mice, trackballs, and light pens are all alternate input¬ devices.

2. Graphic Tablet Keyboard Data Glove Mouse Light Pen Graphic Cards

3. Keyboard Invented 100 years agoUsed to type data into the computer Most common input device today Has special keys for giving the computer commands Commands tell the computer to do something, like save the file These special keys are called command or function keys There is no specific standard but we have stuck to the qwerty keyboard Different types of keyboards It depends what we need to input ATM keyboard, piano keyboard, alarm system keboard etc

4. Types of Keyboard There are following types of Keyboards: 1. ERGONOMIC KEYBOARD The artifact of this keyboard is slightly broader and different in shape, when compared with the normal keyboard. In this key board certain space will be existing between the two sets of keys and the countered shape of this key board allow the users to place their hands in the natural position to type. These key boards are mostly used by the people who often work with the key board as their usage is easier and is less stressful for the wrist. The following figure: Ergonomic keyboard shows how the set of keys are separated with gaps in between.

 5. Types of Keyboard(Cont'd) 2. Wireless Keyboard A wireless keyboard, the name itself doles the meaning that this keyboard can be operated without addressing a wired connection to the processor. The wireless keyboards are also referred as Cordless keyboards; these keyboards require batteries to provide the electricity which usually delivered through a PS/2 or USB cable. "AA" or "AAA" batteries are most widely used standard batteries for wireless keyboards. Apple Macs are known to revolutionize the wireless keyboard by making them thinner than the wired ones. These keyboards usually work at 2.4 GHz frequency and come with a dongle that connects and makes them communicate with the computer.

10 MARKS :

1. **Discuss about Model Representations** .

In 3D computer graphics, 3D modeling (or three-dimensional modeling) is the process of developing a mathematical representation of any *surface* of an object (either inanimate or living) in three dimensions via specialized software. The product is called a 3D model. Someone who works with 3D models may be referred to as a 3D artist. It can be displayed as a two-dimensional image through a process called *3D rendering* or used in a computer simulation of physical phenomena. The model can also be physically created using 3D printing devices.Models may be created automatically or manually. The manual modeling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting.3D modeling software is a class of 3D computer graphics software used to produce 3D models. Individual programs of this class are called modeling applications or modelers.Three-dimensional (3D) models represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3D models can be created by hand, algorithmically (procedural modeling), or scanned. Their surfaces may be further defined with texture mapping.3D models are widely used anywhere in 3D graphics and CAD. Their use predates the widespread use of 3D graphics on personal computers. Many computer games used pre-rendered images of 3D models as sprites before computers could render them in real-time. The designer can then see the model in various directions and views, this can help the designer see if the object is created as intended to compared to their original vision. Seeing the design this way can help the designer/company figure out changes or improvements needed to the product.Today, 3D models are used in a wide variety of fields. The medical industry uses detailed models of organs; these may be created with multiple 2-D image slices from an MRI or

CT scan. The movie industry uses them as characters and objects for animated and real-life motion pictures. The video game industry uses them as assets for computer and video games. The science sector uses them as highly detailed models of chemical compounds.[3] The architecture industry uses them to demonstrate proposed buildings and landscapes in lieu of traditional, physical architectural models. The engineering community uses them as designs of new devices, vehicles and structures as well as a host of other uses. In recent decades the earth science community has started to construct 3D geological models as a standard practice. 3D models can also be the basis for physical devices that are built with 3D printers or CNC machines.

2.Explain in detail about Interactive Picture construction Techniques

1. Interactive Input Methods & Graphical User Input
CGMB 314

2 Learning Outcomes Explain the 6 logical classifications of input devices Differentiate the 7 interactive Picture Construction Techniques

3 Graphical Input Data Types of input data: coordinate positions, attribute values, character-string specifications, geometric-transformation values, viewing conditions, illumination parameters, Input procedures require interaction with display window managers & hardware devices.

4 Logical Classification of Input Devices
Logical input device refers to input devices classified according to data type. LOCATOR – specifies one coordinate position STROKE – specifies a set of coordinate positions STRING – specifies text input VALUATOR – specifies a scalar value CHOICE – specifies menu selection PICK – specifies picture component selection

5 Locator Devices Devices like mouse, joystick,trackball, are used for screen-cursor position General purpose keyboards may have 4 or 8 cursor-control keys Light pen used for interactive input of coordinate position

6 Stroke Devices graphic tablet & continuous movement of mouse, trackball, joystick are used to input a sequence of coordinate positions

7 String Devices primary physical device for string input is keyboard other devices could generate character patterns that is recognized using stored dictionary of predefined patterns for specific application

8 Valuator Devices valuator input is used to set scalar values for geometric transformations, viewing parameters & illumination parameters panel of controls dials typically provides valuator

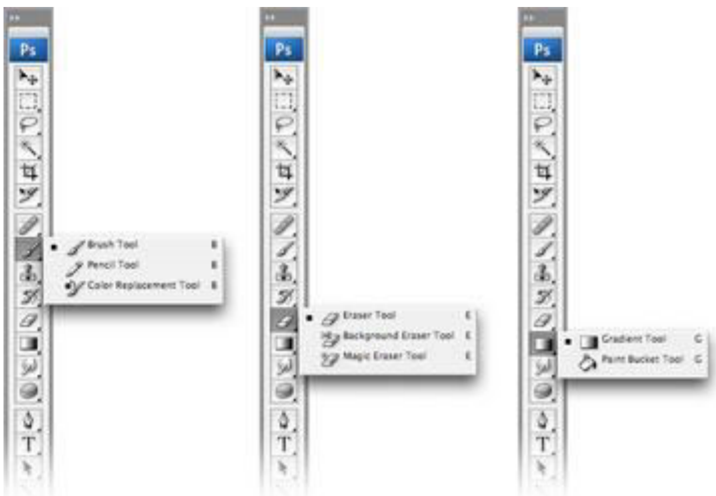
input display graphical representation of slider, buttons, rotating scales, menus Joystick, trackball & keyboard could be adapted for valuator input by movement of the device relative to a scalar range

9 Choice Devices menus are used to select processing options, parameter values & object shapes touch panel, keyboard & voice entry are also common choice devices

10 Pick Devices used to select part of a scene that is to be transformed or edited using mouse, joystick or keyboard, picking the position of screen cursor to identify pixel coordinates depending on type of object & complexity of scene, several levels of search required to identify pick object

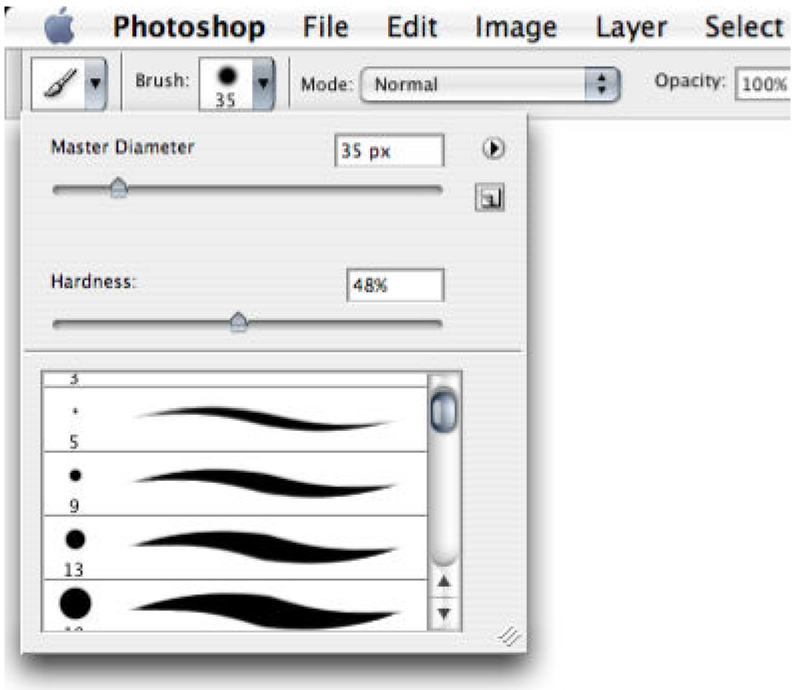
3. Explain about Painting & Drawing in Graphics.

Drawing and Painting Tools



Photoshop provides drawing and painting tools that allow you to create your own shapes and backgrounds.

Brush



The Brush Tool (B) is suitable for soft-edged painting or drawing. Draw strokes by clicking and dragging the mouse over the canvas. You can change the brush size and other settings in the options bar at the top of the window.

Pencil

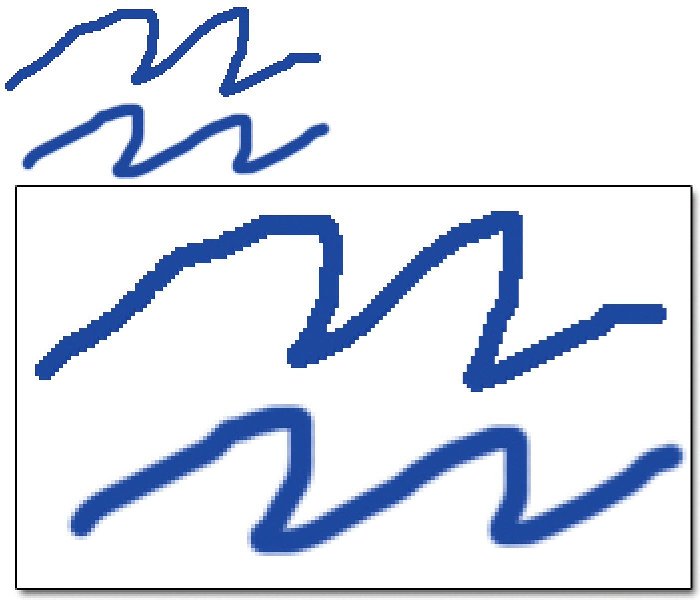
The Pencil Tool (B) is suitable for hard-edged drawing or painting and has similar options to the Brush Tool for setting its size, opacity, and more. The Pencil Tool is often used for drawing on, and editing individual pixels in, zoomed-in images.

Eraser

The Eraser Tool (E) removes pixels from the canvas. You can choose between Pencil, Brush, or Block mode from the Mode drop-down menu in the options bar.

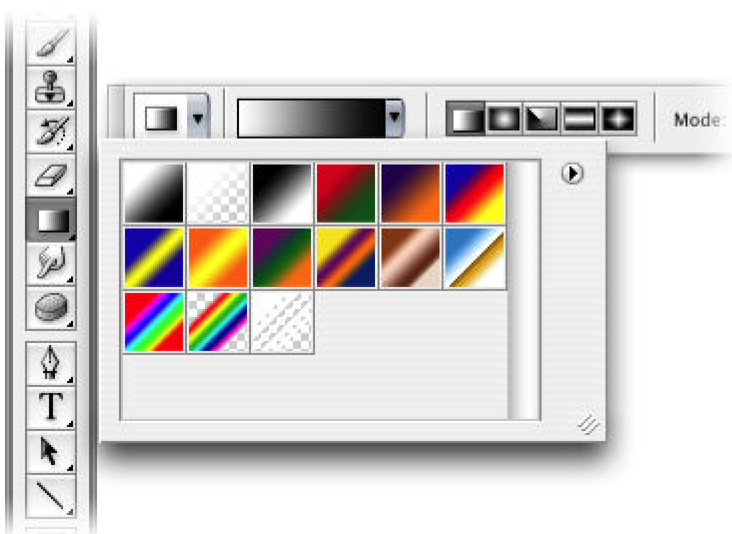
Aliased vs Anti-aliased

Unlike the Brush Tool, the Pencil Tool's edges are aliased. The term aliased refers to the edges of an object being "jagged," in contrast to an anti-aliased object, in which the edges are "smooth." In the two examples shown here, the top shape in each example was created using the Pencil Tool, while the bottom shape was created using the Brush Tool. Notice the difference in the "jaggedness" of the edges of these curves.



Paint Bucket

The Paint Bucket Tool (G) fills a selection with a flat color. To use the Paint Bucket Tool, click once in the area that you wish to fill. If the chosen area is not within a selection, the Paint Bucket Tool will fill all similarly-colored pixels within the vicinity of the clicked area.



Gradient

The Gradient Tool (G) fills a selection with a blend of two or more colors, known as a gradient. You can easily create your own gradient, or use any of the preset gradients available in Photoshop.

Display the gradient presets and tools by clicking on the small triangle on the right-hand side of the Gradient Tool. Apply a gradient by setting your desired colors, choosing your gradient style, then clicking and dragging the cursor over the area to be filled.

UINIT IV

1.Define Three Dimensional Object Representations.

Representation schemes for solid objects are divided into two categories as follows: 1. Boundary Representation (B-reps) 2.. Space Partitioning representation

2.Define Boundary Representation (B-reps)

It describes a three dimensional object as a set of surfaces that separate the object interior from the environment. Examples are polygon facets and spline patches.

3.Define Space Partitioning representation

It describes the interior properties, by partitioning the spatial region containing an object into a set of small, nonoverlapping, contiguous solids(usually cubes). Eg: Octree Representation.

4.Write notes on Polygon Surfaces.

Polygon surfaces are boundary representations for a 3D graphics object is a set of polygons that enclose the object interior.

5.Define Polygon Tables.

The polygon surface is specified with a set of vertex coordinates and associated attribute parameters.

For each polygon input, the data are placed into tables that are to be used in the subsequent processing.

6.What is **Geometric Tables**

Geometric Tables Contain vertex coordinates and parameters to identify the spatial orientation of the polygon surfaces.

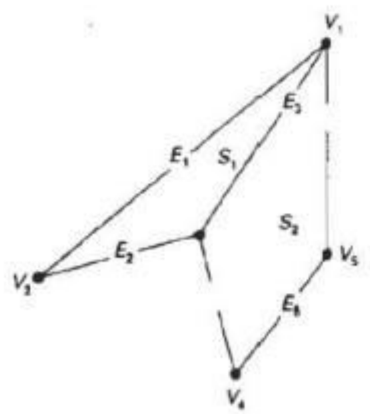
7.Define Attribute tables Contain attribute information for an object such as parameters specifying the degree of transparency of the object and its surface reflectivity and texture characteristics. A convenient organization for storing geometric data is to create three lists:

8. Define Vertex Table

Coordinate values for each vertex in the object are stored in this table. 2. The Edge Table

It contains pointers back into the vertex table to identify the vertices for each polygon edge. 3. The Polygon Table

It contains pointers back into the edge table to identify the edges for each polygon. This is shown in fig



Vertex table	Edge Table	Polygon surface table
$V_1 : X_1, Y_1, Z_1$	$E_1 : V_1, V_2$	$S_1 : E_1, E_2, E_3$
$V_2 : X_2, Y_2, Z_2$	$E_2 : V_2, V_3$	$S_2 : E_3, E_4, E_5, E_6$
$V_3 : X_3, Y_3, Z_3$	$E_3 : V_3, V_1$	
$V_4 : X_4, Y_4, Z_4$	$E_4 : V_3, V_4$	
$V_5 : X_5, Y_5, Z_5$	$E_5 : V_4, V_5$	
	E6 : V_5, V_1	

9. Write short notes on Plane Equations:

To produce a display of a 3D object, we must process the input data representation for the object through several procedures such as,

- Transformation of the modeling and world coordinate descriptions to viewing coordinates.
- Then to device coordinates:
- Identification of visible surfaces
- The application of surface-rendering procedures.

10.Define Polygon Meshes

A single plane surface can be specified with a function such as **fillArea**. But when object surfaces are to be tiled, it is more convenient to specify the surface facets with a mesh function. One type of polygon mesh is the **triangle strip**.A triangle strip formed with 11 triangles connecting 13 vertices.

11.how to draw Spline Representations A Spline is a flexible strip used to produce a smooth curve through a designated set of points. Several small weights are distributed along the length of the strip to hold it in position on the drafting table as the curve is drawn.

12.**Define convex hull**

Interpolation curves are used to digitize drawings or to specify animation paths. Approximation curves are used as design tools to structure object surfaces. A spline curve is designed , modified and manipulated with operations on the control points.The curve can be translated, rotated or scaled with transformation applied to the control points. The convex polygon boundary that encloses a set of control points is called the **convex hull**.

13.What are the conditions in Geometric Continuity ?

To specify conditions for geometric continuity is an alternate method for joining two successive curve sections.

First order Geometric Continuity referred as G1 continuity means that the parametric first derivatives are proportional at the interaction of two successive sections.

Second order Geometric continuity referred as G2 continuity means that both the first and second parametric derivatives of the two curve sections are proportional at their boundary. Here the curvatures of two sections will match at the joining position.

14.Define 3D Translation

Translation

$$\begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

A translation in space is described by tx, ty and tz. It is easy to see that this matrix realizes the equations:

x2=x1+tx
y2=y1+ty
z2=z1+tz

15. Scaling

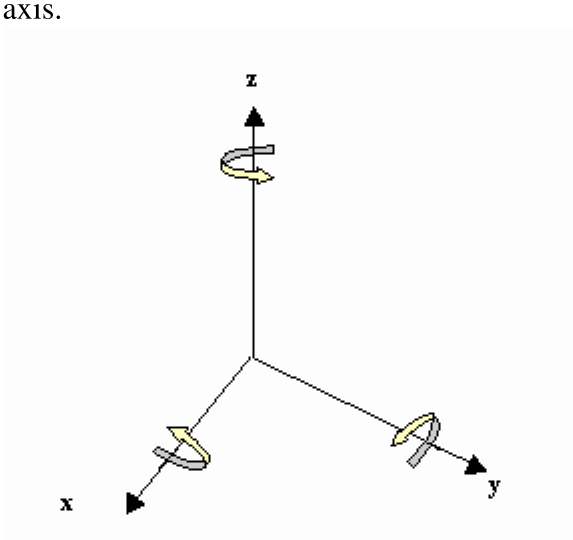
$$\begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & t_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Scaling in space is described by sx, sy and sz. We see that this matrix realizes the following equations:

x2=x1·sx
y2=y1·sy
z2=z1·sz

16.Rotation

Rotation is a bit more complicated. We define three different basic rotations, one around every axis.



Around the Z-axis Around the X-axis Around the Y-axis

$$\begin{bmatrix} cos(v) & -sin(v) & 0 & 0 \\ sin(v) & cos(v) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & cos(v) & -sin(v) & 0 \\ 0 & sin(v) & cos(v) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} cos(v) & 0 & sin(v) & 0 \\ 0 & 1 & 0 & 0 \\ -sin(v) & 0 & cos(v) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

17.Shears In 3-D

Shearing transformations are used to distortions in the shape of an object. In 2D, shearing is applied to x or y axes. In 3D it can applied to z axis also

The following transformation produces an Z axis shear

$$SHz = \begin{bmatrix} 1 & 0 & a & 0 \\ 0 & 1 & b & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Parameters a and b can be assigned any real values

5 MARKS

1.How three dimensional object is represented?

Representation schemes for solid objects are divided into two categories as follows: 1. Boundary Representation (B-reps) It describes a three dimensional object as a set of surfaces that separate the object interior from the environment. Examples are polygon facets and spline patches.2. Space Partitioning representation.It describes the interior properties, by partitioning the spatial region containing an object into a set of small, nonoverlapping, contiguous solids(usually cubes). Eg: Octree Representation.

Polygon Surfaces

Polygon surfaces are boundary representations for a 3D graphics object is a set of polygons that enclose the object interior.

Polygon Tables

The polygon surface is specified with a set of vertex coordinates and associated attribute parameters.For each polygon input, the data are placed into tables that are to be used in the subsequent processing.Polygon data tables can be organized into two groups: Geometric tables and attribute tables.

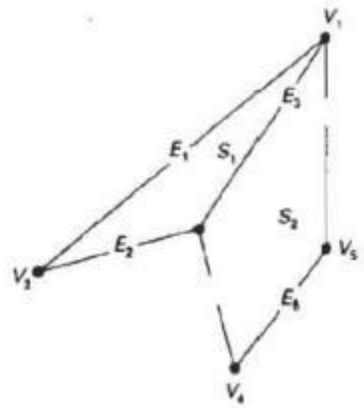
Geometric Tables Contain vertex coordinates and parameters to identify the spatial orientation of the polygon surfaces.

Attribute tables Contain attribute information for an object such as parameters specifying the degree of transparency of the object and its surface reflectivity and texture characteristics. A convenient organization for storing geometric data is to create three lists:

1. The Vertex Table:Coordinate values for each vertex in the object are stored in this table.

2. The Edge Table:It contains pointers back into the vertex table to identify the vertices for each polygon edge.

3. The Polygon Table:It contains pointers back into the edge table to identify the edges for each polygon. This is shown in fig



Vertex table	Edge Table	Polygon surface table
$V_1 : X_1, Y_1, Z_1$	$E_1 : V_1, V_2$	$S_1 : E_1, E_2, E_3$
$V_2 : X_2, Y_2, Z_2$	$E_2 : V_2, V_3$	$S_2 : E_3, E_4, E_5, E_6$
$V_3 : X_3, Y_3, Z_3$	$E_3 : V_3, V_1$	
$V_4 : X_4, Y_4, Z_4$	$E_4 : V_3, V_4$	
$V_5 : X_5, Y_5, Z_5$	$E_5 : V_4, V_5$	
	$E6 : V_5, V_1$	

Listing the geometric data in three tables provides a convenient reference to the individual components (vertices, edges and polygons) of each object.The object can be displayed efficiently by using data from the edge table to draw the component lines.Extra information can be added to the data tables for faster information extraction. For instance, edge table can be expanded to include forward points into the polygon table so that common edges between polygons can be identified more rapidly.

E1 : V1, V2, S1

E2 : V2, V3, S1

E3 : V3, V1, S1, S2

E4 : V3, V4, S2

E5 : V4, V5, S2

E6 : V5, V1, S2

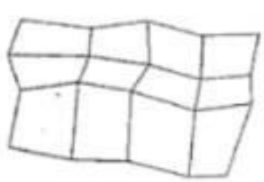
is useful for the rendering procedure that must vary surface shading smoothly across the edges from one polygon to the next. Similarly, the vertex table can be expanded so that vertices are cross-referenced to corresponding edges.

2.Explain polygon meshes in brief.

A single plane surface can be specified with a function such as **fillArea**. But when object surfaces are to be tiled, it is more convenient to specify the surface facets with a mesh function. One type of polygon mesh is the **triangle strip**.A triangle strip formed with 11 triangles connecting 13 vertices.

This function produces n-2 connected triangles given the coordinates for n vertices.

Another similar function in the **quadrilateral mesh**, which generates a mesh of (n-1) by (m-1) quadrilaterals, given the coordinates for an n by m array of vertices. Figure shows 20 vertices forming a mesh of 12 quadrilaterals.



Curved Lines and Surfaces Displays of three dimensional curved lines and surface can be generated from an input set of mathematical functions defining the objects or from a set of user specified data points. When functions are specified, a package can project the defining equations for a curve to the display plane and plot pixel positions along the path of the projected function. For surfaces, a functional description in decorated to produce a polygon-mesh approximation to the surface.

Spline Representations A Spline is a flexible strip used to produce a smooth curve through a designated set of points. Several small weights are distributed along the length of the strip to hold it in position on the drafting table as the curve is drawn.

The **Spline curve** refers to any sections curve formed with polynomial sections satisfying specified continuity conditions at the boundary of the pieces.

A **Spline surface** can be described with two sets of orthogonal spline curves. Splines are used in graphics applications to design curve and surface shapes, to digitize drawings for computer storage, and to specify animation paths for the objects or the camera in the scene. CAD applications for splines include the design of automobiles bodies, aircraft and spacecraft surfaces, and ship hulls.

Interpolation and Approximation Splines Spline curve can be specified by a set of coordinate positions called **control points** which indicates the general shape of the curve. These control points are fitted with piecewise continuous parametric polynomial functions in one of the two ways. 1. When polynomial sections are fitted so that the curve passes through each control point the resulting curve is said to **interpolate** the set of control points.

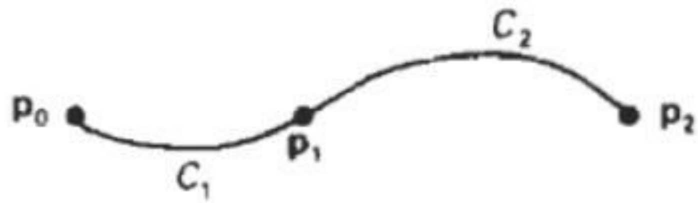
A set of six control points interpolated with piecewise continuous polynomial sections

1. When the polynomials are fitted to the general control point path without necessarily passing through any control points, the resulting curve is said to **approximate** the set of control points.

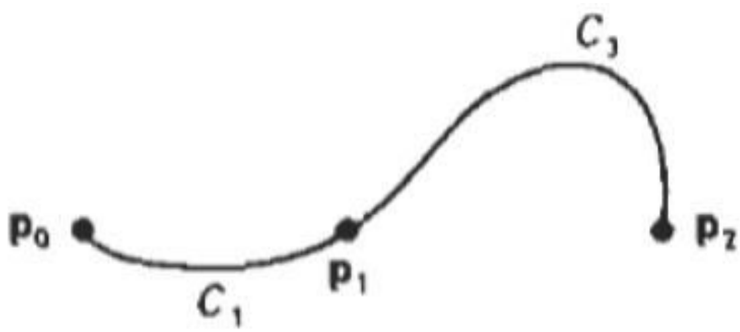
A set of six control points approximated with piecewise continuous polynomial sections

Interpolation curves are used to digitize drawings or to specify animation paths. Approximation curves are used as design tools to structure object surfaces. A spline curve is designed , modified and manipulated with operations on the control points.The curve can be translated, rotated or scaled with transformation applied to the control points. The convex polygon boundary that encloses a set of control points is called the **convex hull**. The shape of the convex hull is to imagine a rubber band stretched around the position of the control points so that each control point is either on the perimeter of the hull or inside it. **Convex hull shapes (dashedlines) for two sets of control points**

Tow control points fitted with two curve sections joined with a) parametric continuity



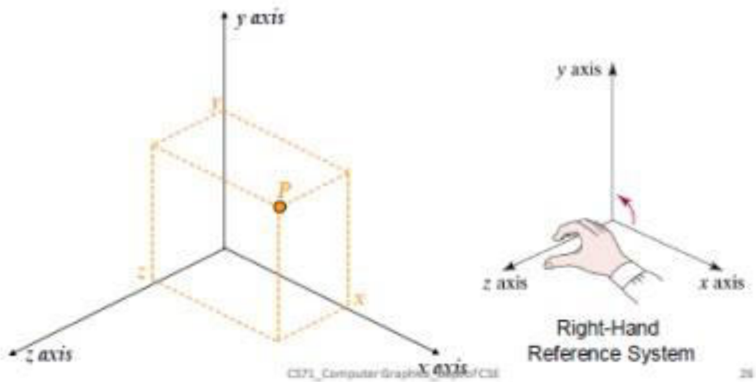
b)geometric continuity where the tangent vector of curve C3 at point p1 has a greater magnitude than the tangent vector of curve C1 at p1.



(b)

10 MARKS

1. Write brief notes on 3-D Coordinate Spaces.

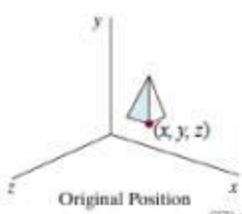


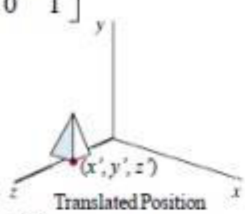
Translations In 3-D

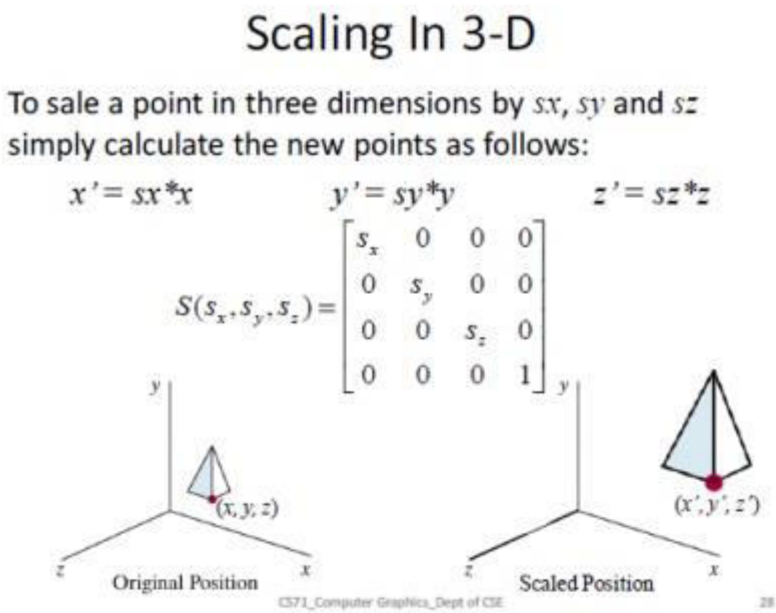
To translate a point in three dimensions by dx, dy and dz .calculate the new points as follows:

$$x' = x + dx \quad y' = y + dy \quad z' = z + dz$$

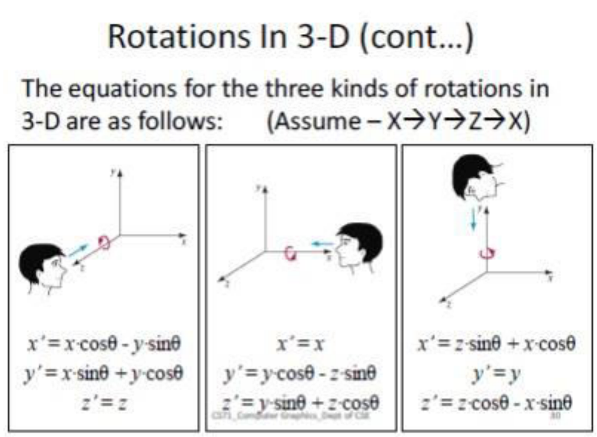
$$T(d_x, d_y, d_z) = \begin{bmatrix} 1 & 0 & 0 & d_x \\ 0 & 1 & 0 & d_y \\ 0 & 0 & 1 & d_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

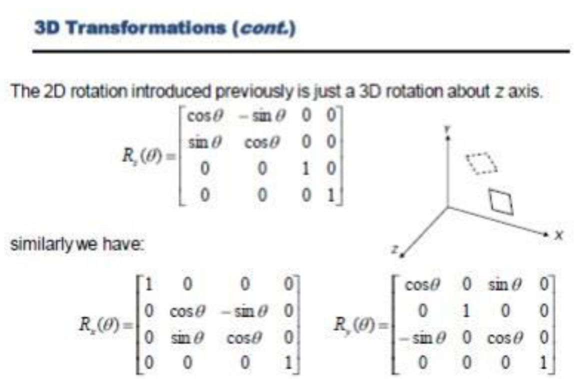






Rotations In 3-D When we performed rotations in two dimensions we only had the choice of rotating about the z axis In the case of three dimensions we have more options – Rotate about x – Rotate about y – Rotate about z





3D Transformation Matrices

Translation by dx, dy, dz:

$$\begin{bmatrix} 1 & 0 & 0 & dx \\ 0 & 1 & 0 & dy \\ 0 & 0 & 1 & dz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Scaling by sx, sy, sz:

$$\begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Rotate About X-Axis

$$\begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Rotate About Y-Axis

$$\begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Rotate About Z-Axis

General 3D Rotations • Rotation about an axis that is parallel to one of the coordinate axes : 1. Translate the object so that the rotation axis coincides with the parallel coordinate axis 2. Perform the specified rotation about the axis 3. Translate the object so that the rotation axis is moved back to its original position • Not parallel : 1. Translate the object so that the rotation axis passes through the coordinate origin 2. Rotate the object so that the axis of rotation coincides with one of the coordinate axes 3. Perform the specified rotation about the axis 4. Apply inverse rotations to bring the rotation axis back to its original orientation 5. Apply the inverse translation to bring back the rotation axis to its original position3 D Transformation functions • Functions are – translate3(translateVector, matrixTranslate) – rotateX(thetaX, xMatrixRotate) – rotateY(thetaY, yMatrixRotate) – rotateZ(thetaZ, zMatrixRotate) – scale3(scaleVector,matrixScale) • To apply transformation matrix to the specified points , – transformPoint3(inPoint, matrix,outPoint) • We can construct composite transformations with the following functions – composeMatrix3 – buildTransformationMatrix3 – composeTransformationMatrix3 CS71_Computer Graphics_Dept of CSE 34 Reflections In 3-D • Three Dimensional Reflections can be performed relative to a selected reflection axis or a selected reflection plane • Consider a reflection that converts coordinate specifications from a right handed system to left handed system. • This transformation changes the sign of Z coordinate leaving x and y coordinates

$$T(d_x, d_y, d_z) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. Explain the shears in 3-D?

Shearing transformations are used to distortions in the shape of an object. In 2D, shearing is applied to x or y axes. In 3D it can applied to z axis also

The following transformation produces an Z axis shear

$$SHz = \begin{bmatrix} 1 & 0 & a & 0 \\ 0 & 1 & b & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Parameters a and b can be assigned any real values

Shearing: Shearing transformations in three-dimensions alter two of the three coordinate values proportionally to the value of the third coordinate.

X-Shearing: X-shearing a frame: We ``x-shear'' a frame by modifying the first vector of the frame by adding to it a linear combination of the other two vectors. X-shearing a point:The X-shear transformation matrix can be defined by

Y-Shearing: Y-shearing a frame:Y-shearing a point.The Y-shear transformation matrix can be defined by Z-Shearing:Z-shearing a frame:Z-shearing a point.The Z-shear transformation matrix can be defined by.The Z-shear transformation matrix can be defined.

UNIT V

1.What is visible surface detection?

When we view a picture containing non-transparent objects and surfaces, then we cannot see those objects from view which are behind from objects closer to eye. We must remove these hidden surfaces to get a realistic screen image. The identification and removal of these surfaces is called **Hidden-surface problem**.

2.What are the methods in surface rendering?

There are two approaches for removing hidden surface problems − **Object-Space method** and **Image-space method**. The Object-space method is implemented in physical coordinate system and image-space method is implemented in screen coordinate system.
When we want to display a 3D object on a 2D screen, we need to identify those parts of a screen that are visible from a chosen viewing position.

3.Define Depth Buffer (Z-Buffer) Method

This method is developed by Cutmull. It is an image-space approach. The basic idea is to test the Z-depth of each surface to determine the closest (visible) surface.
In this method each surface is processed separately one pixel position at a time across the surface. The depth values for a pixel are compared and the closest (smallest z) surface determines the color to be displayed in the frame buffer.

4.What are the Advantages in Depth Buffer (Z-Buffer) Method ?

- It reduces the speed problem if implemented in hardware.
- It processes one object at a time.

5.What are Disadvantages in Depth Buffer (Z-Buffer) Method

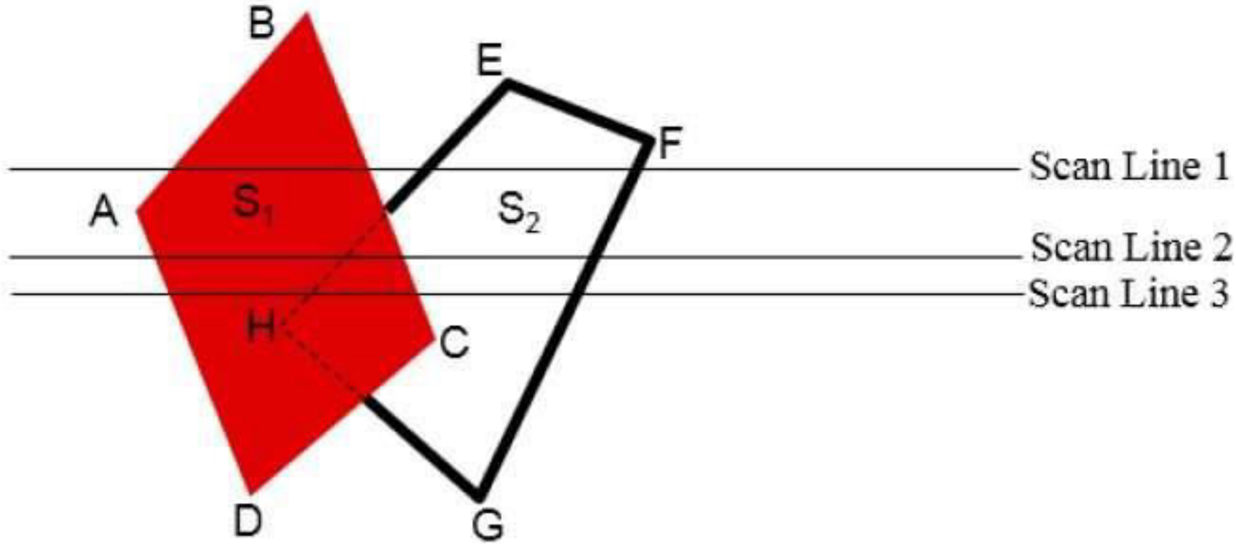
- It requires large memory.
- It is time consuming process.

6.Scan-Line Method

It is an image-space method to identify visible surface. This method has a depth information for only single scan-line. In order to require one scan-line of depth values, we must group and process all polygons intersecting a given scan-line at the same time .

7.Define The Edge Table − It contains coordinate endpoints of each line in the scene, the inverse slope of each line, and pointers into the polygon table to connect edges to surfaces.

8. Define The Polygon Table − It contains the plane coefficients, surface material properties, other surface data, and may be pointers to the edge table.



9.Define Area-Subdivision Method

The area-subdivision method takes advantage by locating those view areas that represent part of a single surface. Divide the total viewing area into smaller and smaller rectangles until each small area is the projection of part of a single visible surface or no surface at all.

.**Surrounding surface** − One that completely encloses the area.

- **Overlapping surface** − One that is partly inside and partly outside the area.
- **Inside surface** − One that is completely inside the area.
- **Outside surface** − One that is completely outside the area.

10.Define Buffer Method

The A-buffer method is an extension of the depth-buffer method. The A-buffer method is a visibility detection method developed at Lucas film Studios for the rendering system Renders Everything You Ever Saw (REYES).

[redacted]

[redacted]pth sorting method uses both image space and object-space operations. The depth-sorting method performs two basic functions −

- First, the surfaces are sorted in order of decreasing depth.
- Second, the surfaces are scan-converted in order, starting with the surface of greatest depth.

12.Define Binary Space Partition (BSP) Trees

Binary space partitioning is used to calculate visibility. To build the BSP trees, one should start with polygons and label all the edges. Dealing with only one edge at a time, extend each edge so that it splits the plane in two. Place the first edge in the tree as root. Add subsequent edges based on whether they are inside or outside. Edges that span the extension of an edge that is already in

13. DefineColor Models

Color Model is a method for explaining the properties or behavior of color within some particular context. No single color model can explain all aspects of color, so we make use of different models to help describe the different perceived characteristics of color.

14.Write notes on XYZ Color.

The set of primaries is generally referred to as the XYZ or (X,Y,Z) color model

where X,Y and Z represent vectors in a 3D, additive color space.

15.Define RGB Color Model

Based on the tristimulus theory of version, our eyes perceive color through the stimulation of three visual pigments in the cones on the retina.

These visual pigments have a peak sensitivity at wavelengths of about 630 nm (red), 530 nm (green) and 450 nm (blue).

16. Define YIQ Color Model

In the YIQ color model, luminance (brightness) information in contained in the Y parameter, chromaticity information (hue and purity) is contained into the I and Q parameters.

17.Define Color Model

A color model defined with the primary colors cyan, magenta, and yellow (CMY) in useful for describing color output to hard copy devices.

18.HSV Color Model

Color parameters in this model are hue (H), saturation (S), and value (V). The 3D representation of the HSV model is derived from the RGB cube. The outline of the cube has the hexagon shape.

19.Define HLS Color Model

HLS model is based on intuitive color parameters used by Tektronix.

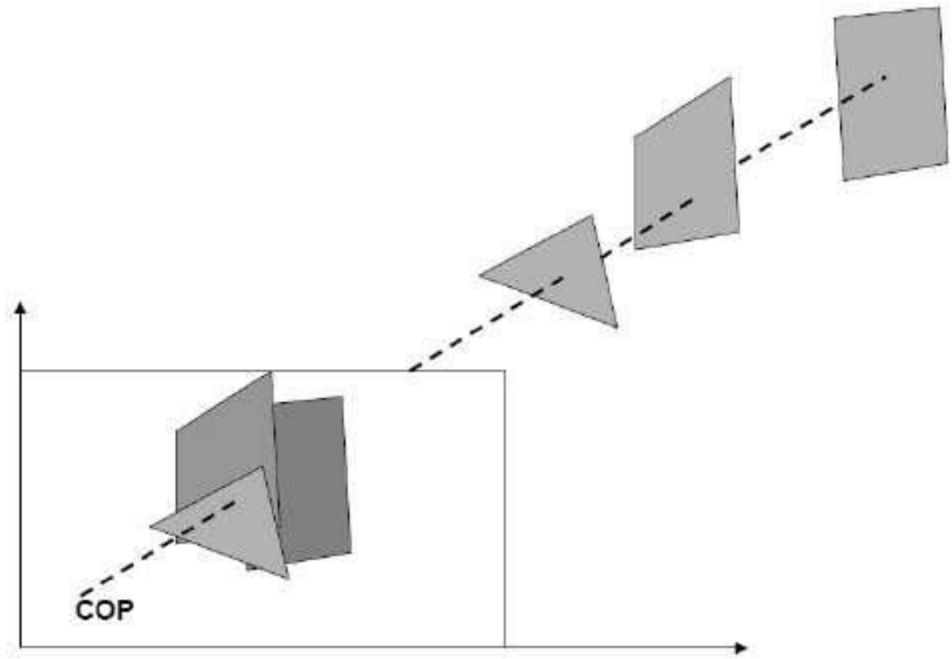
It has the double cone representation shown in the below figure. The 3 parameters in this model are called Hue (H), lightness (L) and saturation (s).

5 MARKS

1. Explain the Depth Buffer (Z-Buffer) Method of visible from viewing position.

This method is developed by Cutmull. It is an image-space approach. The basic idea is to test the Z-depth of each surface to determine the closest (visible) surface.In this method each surface is processed separately one pixel position at a time across the surface. The depth values for a pixel are compared and the closest (smallest z) surface determines the color to be displayed in the frame buffer.It is applied very efficiently on surfaces of polygon. Surfaces can be processed in any order. To override the closer polygons from the far ones, two buffers named **frame buffer** and **depth buffer,** are used.

Depth buffer is used to store depth values for (x, y) position, as surfaces are processed ($0 \leq$ depth ≤ 1).The **frame buffer** is used to store the intensity value of color value at each position (x, y). The z-coordinates are usually normalized to the range [0, 1]. The 0 value for z-coordinate indicates back clipping pane and 1 value for z-coordinates indicates front clipping pane.



Algorithm

Step-1 − Set the buffer values −

Depthbuffer (x, y) = 0

Framebuffer (x, y) = background color

Step-2 − Process each polygon (One at a time)

For each projected (x, y) pixel position of a polygon, calculate depth z.

If Z > depthbuffer (x, y)

Compute surface color,

set depthbuffer (x, y) = z,

framebuffer (x, y) = surfacecolor (x, y)

Advantages

- It is easy to implement.
- It reduces the speed problem if implemented in hardware.
- It processes one object at a time.

Disadvantages

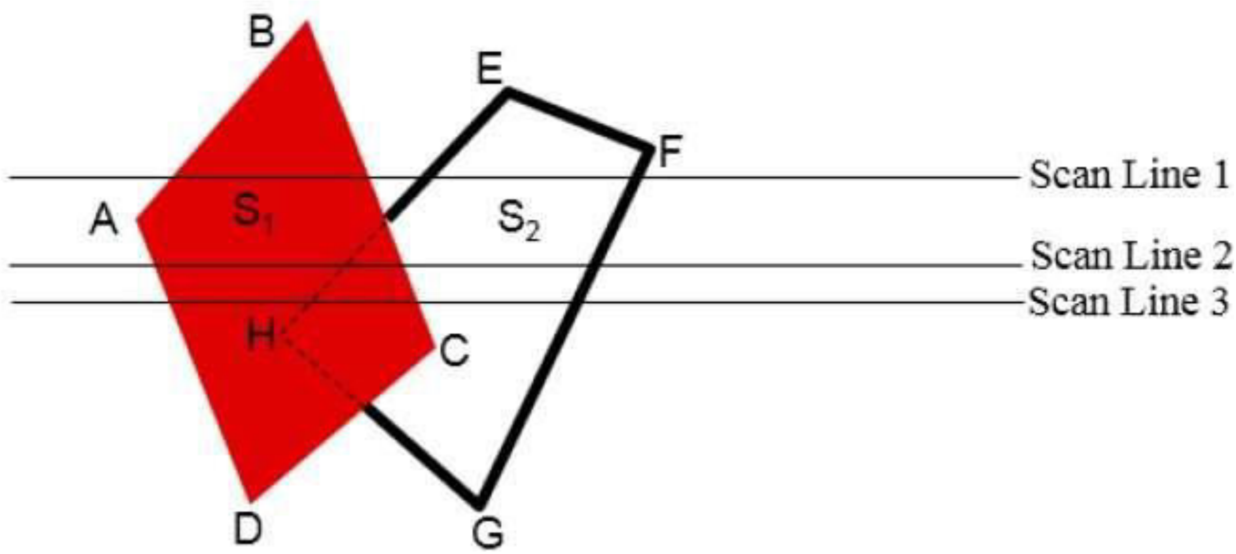
- It requires large memory.
- It is time consuming process.

2.How Scan-Line Method identifies the visible surface.

It is an image-space method to identify visible surface. This method has a depth information for only single scan-line. In order to require one scan-line of depth values, we must group and process all polygons intersecting a given scan-line at the same time before processing the next scan-line. Two important tables, **edge table** and **polygon table,** are maintained for this.

The Edge Table − It contains coordinate endpoints of each line in the scene, the inverse slope of each line, and pointers into the polygon table to connect edges to surfaces.

The Polygon Table − It contains the plane coefficients, surface material properties, other surface data, and may be pointers to the edge table.



To facilitate the search for surfaces crossing a given scan-line, an active list of edges is formed. The active list stores only those edges that cross the scan-line in order of increasing x. Also a flag is set for each surface to indicate whether a position along a scan-line is either inside or outside the surface.

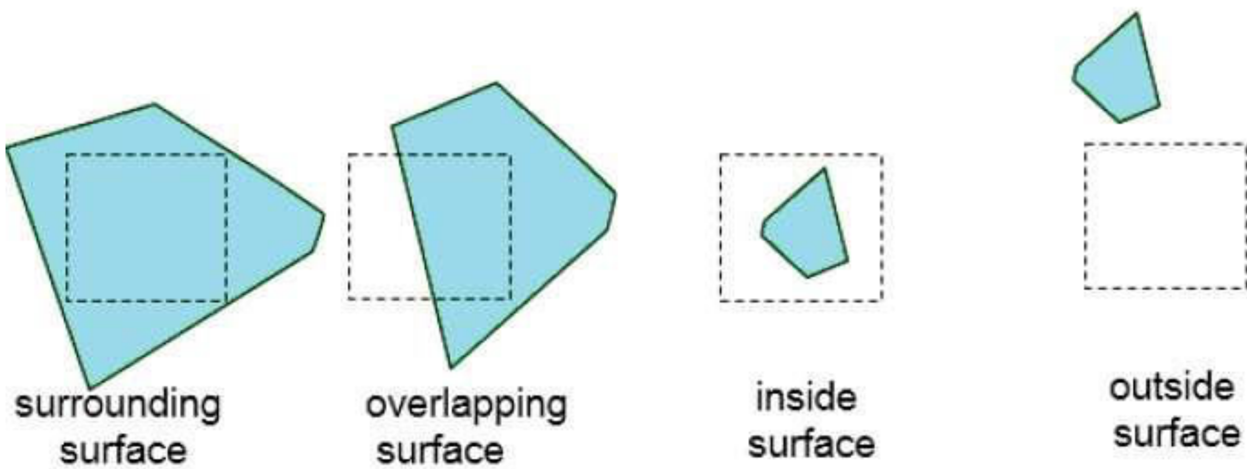
Pixel positions across each scan-line are processed from left to right. At the left intersection with a surface, the surface flag is turned on and at the right, the flag is turned off. You only need to perform depth calculations when multiple surfaces have their flags turned on at a certain scan-line position.

3.Discuss the Area-Subdivision Method in viewing.

The area-subdivision method takes advantage by locating those view areas that represent part of a single surface. Divide the total viewing area into smaller and smaller rectangles until each small area is the projection of part of a single visible surface or no surface at all.

Continue this process until the subdivisions are easily analyzed as belonging to a single surface or until they are reduced to the size of a single pixel. An easy way to do this is to successively divide the area into four equal parts at each step. There are four possible relationships that a surface can have with a specified area boundary.

- **Surrounding surface** − One that completely encloses the area.
- **Overlapping surface** − One that is partly inside and partly outside the area.
- **Inside surface** − One that is completely inside the area.
- **Outside surface** − One that is completely outside the area.



The tests for determining surface visibility within an area can be stated in terms of these four classifications. No further subdivisions of a specified area are needed if one of the following conditions is true −

- All surfaces are outside surfaces with respect to the area.
- Only one inside, overlapping or surrounding surface is in the area.
- A surrounding surface obscures all other surfaces within the area boundaries.

4.Explain the Back-Face Detection positioning

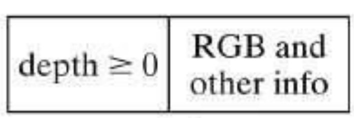
A fast and simple object-space method for identifying the back faces of a polyhedron is based on the "inside-outside" tests. A point (x, y, z) is "inside" a polygon surface with plane parameters A, B, C, and D if When an inside point is along the line of sight to the surface, the polygon must be a back face (we are inside that face and cannot see the front of it from our viewing position).We can simplify this test by considering the normal vector **N** to a polygon surface, which has Cartesian components (A, B, C).In general, if V is a vector in the viewing direction from the eye (or "camera") position, then this polygon is a back face if**V.N > 0.**Furthermore, if object descriptions are converted to projection coordinates and your viewing direction is parallel to the viewing z-axis, then $-V = (0, 0, V_z)$ and $V.N = V_Z C$.So that we only need to consider the sign of C the component of the normal vector **N**.In a right-handed viewing system with viewing direction along the negative ZVaxis, the polygon is a back face if C < 0. Also, we cannot see any face whose normal has z component C = 0, since your viewing direction is towards that polygon. Thus, in general, we can label any polygon as a back face if its normal vector has a z component value −**C <= 0.**Similar methods can be used in packages that employ a left-handed viewing system. In these packages, plane parameters A, B, C and D can be calculated from polygon vertex coordinates specified in a clockwise direction (unlike the counterclockwise direction used in a right-handed system).Also, back faces have normal vectors that point away from the viewing position and are identified by C >= 0 when the viewing direction is along the positive Zv

axis. By examining parameter C for the different planes defining an object, we can immediately identify all the back faces.

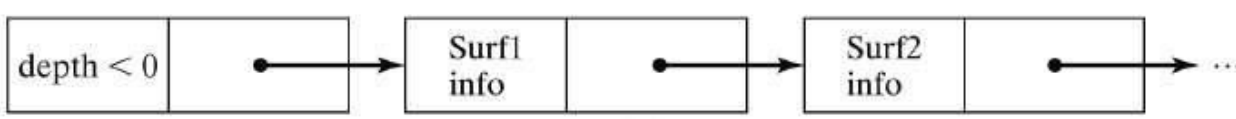
5.Write notes on A-Buffer Method.

The A-buffer method is an extension of the depth-buffer method. The A-buffer method is a visibility detection method developed at Lucas film Studios for the rendering system Renders Everything You Ever Saw (REYES).The A-buffer expands on the depth buffer method to allow transparencies. The key data structure in the A-buffer is the accumulation bufferEach position in the A-buffer has two fields −

- **Depth field** − It stores a positive or negative real number
- **Intensity field** − It stores surface-intensity information or a pointer value



(a)



(b)

If depth >= 0, the number stored at that position is the depth of a single surface overlapping the corresponding pixel area. The intensity field then stores the RGB components of the surface color at that point and the percent of pixel coverage.

If depth < 0, it indicates multiple-surface contributions to the pixel intensity. The intensity field then stores a pointer to a linked list of surface data. The surface buffer in the A-buffer includes −

- RGB intensity components
- Opacity Parameter
- Depth
- Percent of area coverage
- Surface identifier

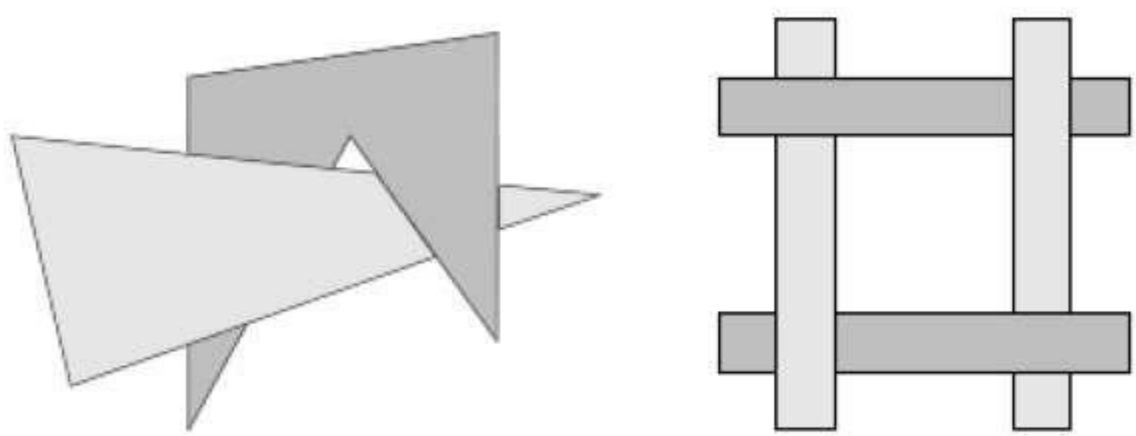
The algorithm proceeds just like the depth buffer algorithm. The depth and opacity values are used to determine the final color of a pixel.

6. Explain the Depth Sorting Method in brief.

Depth sorting method uses both image space and object-space operations. The depth-sorting method performs two basic functions −

- First, the surfaces are sorted in order of decreasing depth.
- Second, the surfaces are scan-converted in order, starting with the surface of greatest depth.

The scan conversion of the polygon surfaces is performed in image space. This method for solving the hidden-surface problem is often referred to as the **painter's algorithm**. The following figure shows the effect of depth sorting −



The algorithm begins by sorting by depth. For example, the initial "depth" estimate of a polygon may be taken to be the closest z value of any vertex of the polygon.

Let us take the polygon P at the end of the list. Consider all polygons Q whose z-extents overlap P's. Before drawing P, we make the following tests. If any of the following tests is positive, then we can assume P can be drawn before Q.

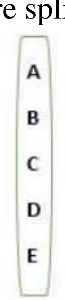
- Do the x-extents not overlap?

- Do the y-extents not overlap?
- Is P entirely on the opposite side of Q's plane from the viewpoint?
- Is Q entirely on the same side of P's plane as the viewpoint?
- Do the projections of the polygons not overlap?

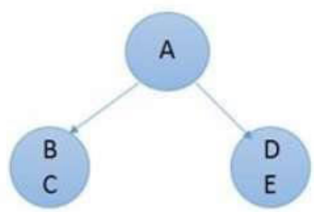
If all the tests fail, then we split either P or Q using the plane of the other. The new cut polygons are inserting into the depth order and the process continues. Theoretically, this partitioning could generate $O(n^2)$ individual polygons, but in practice, the number of polygons is much smaller.

7.Explain the binary space partition (BSP) trees.

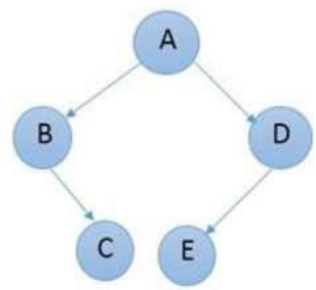
Binary space partitioning is used to calculate visibility. To build the BSP trees, one should start with polygons and label all the edges. Dealing with only one edge at a time, extend each edge so that it splits the plane in two. Place the first edge in the tree as root. Add subsequent edges based on whether they are inside or outside. Edges that span the extension of an edge that is already in the tree are split into two and both are added to the tree.



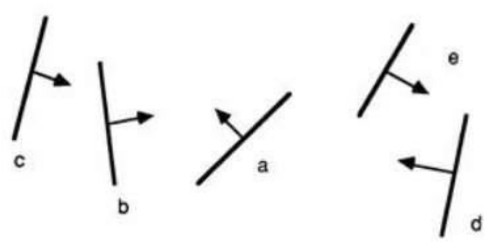
(a)



(b)



(c)



(d)

- From the above figure, first take **A** as a root.
- Make a list of all nodes in figure (a).
- Put all the nodes that are in front of root **A** to the left side of node **A** and put all those nodes that are behind the root **A** to the right side as shown in figure (b).
- Process all the front nodes first and then the nodes at the back.
- As shown in figure (c), we will first process the node **B**. As there is nothing in front of the node **B**, we have put NIL. However, we have node **C** at back of node **B**, so node **C** will go to the right side of node **B**.
- Repeat the same process for the node **D**.

8. How XYZ Color are referred to color model?

The set of primaries is generally referred to as the XYZ or (X,Y,Z) color model

where X,Y and Z represent vectors in a 3D, additive color space.Any color Cλ is expressed as

$$C\lambda = X\mathbf{X} + Y\mathbf{Y} + Z\mathbf{Z} \text{-------------} \qquad (1)$$

Where X,Y and Z designates the amounts of the standard primaries needed

to match Cλ.It is convenient to normalize the amount in equation (1) against luminance (X+ Y+ Z). Normalized amounts are calculated as,x = X/(X+Y+Z), y = Y/(X+Y+Z), z = Z/(X+Y+Z)with x + y + z = 1.Any color can be represented with just the x and y amounts. The parameters x and y are called the chromaticity values because they depend only on hue and purity.If we specify colors only with x and y, we cannot obtain the amounts X, Y and Z. so, a complete description of a color in given with the 3 values x, y and Y.X = (x/y)Y, Z = (z/y)Y Where z = 1-x-y.

10 Marks

1.Explain the visible surface detection of objects.

When we view a picture containing non-transparent objects and surfaces, then we cannot see those objects from view which are behind from objects closer to eye. We must remove these hidden surfaces to get a realistic screen image. The identification and removal of these surfaces is called **Hidden-surface problem**.

There are two approaches for removing hidden surface problems − **Object-Space method** and **Image-space method**. The Object-space method is implemented in physical coordinate system and image-space method is implemented in screen coordinate system.

When we want to display a 3D object on a 2D screen, we need to identify those parts of a screen that are visible from a chosen viewing position.

Depth Buffer (Z-Buffer) Method

This method is developed by Cutmull. It is an image-space approach. The basic idea is to test the Z-depth of each surface to determine the closest (visible) surface.

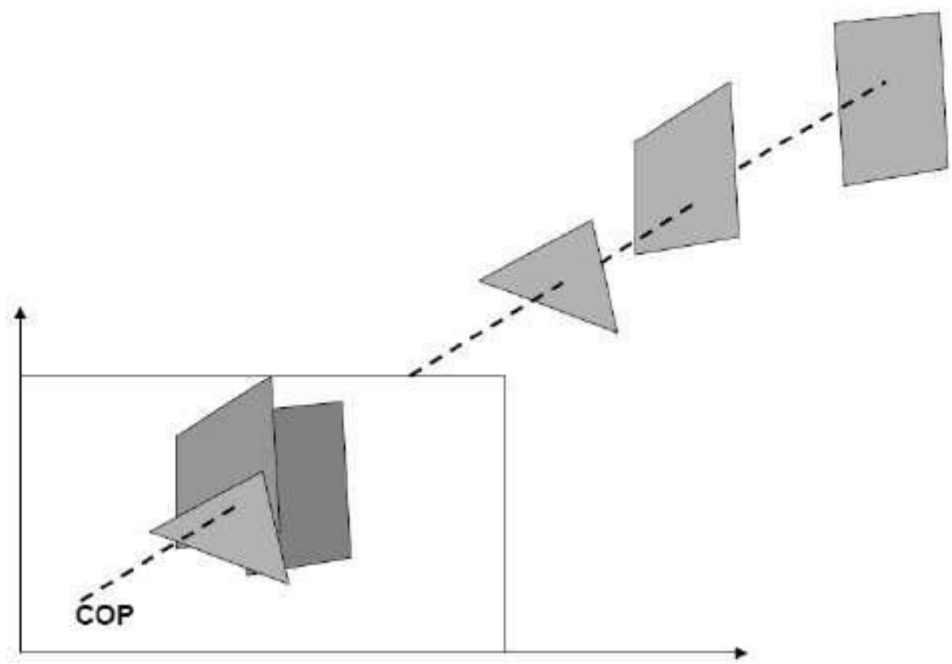
In this method each surface is processed separately one pixel position at a time across the surface. The depth values for a pixel are compared and the closest (smallest z) surface determines the color to be displayed in the frame buffer.

It is applied very efficiently on surfaces of polygon. Surfaces can be processed in any order. To override the closer polygons from the far ones, two buffers named **frame buffer** and **depth buffer,** are used.

Depth buffer is used to store depth values for (x, y) position, as surfaces are processed (0 ≤ depth ≤ 1).

The **frame buffer** is used to store the intensity value of color value at each position (x, y).

The z-coordinates are usually normalized to the range [0, 1]. The 0 value for z-coordinate indicates back clipping pane and 1 value for z-coordinates indicates front clipping pane.



Algorithm

Step-1 − Set the buffer values −

Depthbuffer (x, y) = 0

Framebuffer (x, y) = background color

Step-2 − Process each polygon (One at a time)

For each projected (x, y) pixel position of a polygon, calculate depth z.

If Z > depthbuffer (x, y)

Compute surface color,

set depthbuffer (x, y) = z,

framebuffer (x, y) = surfacecolor (x, y)

Advantages

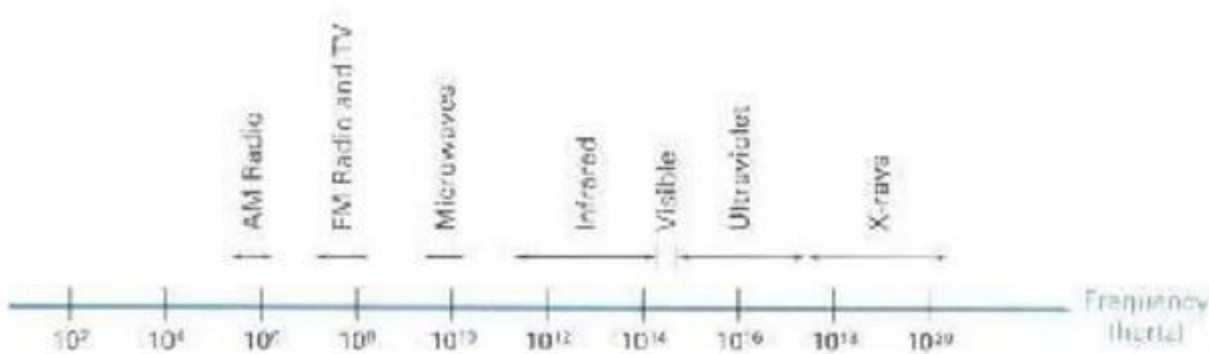
- It is easy to implement.
- It reduces the speed problem if implemented in hardware.
- It processes one object at a time.

Disadvantages

- It requires large memory.
- It is time consuming process.

2.Explain the properties of illumination models and surface rendering methods.

Light is a narrow frequency band within the electromagnetic system.Other frequency bands within this spectrum are called radio waves, micro waves, infrared waves and x-rays. The below fig shows the frequency ranges for some of the electromagnetic bands.



Each frequency value within the visible band corresponds to a distinct color.At the low frequency end is a red color ($4.3*10^4$ Hz) and the highest frequency is a violet color ($7.5 *10^{14}$Hz)Spectral colors range from the reds through orange and yellow at the low frequency end to greens, blues and violet at the high end.Since light is an electro magnetic wave, the various colors are described in terms of either the frequency for the wave length λ of the wave.The wave length ad frequency of the monochromatic wave are inversely proportional to each other, with the proportionality constants as the speed of light C where $C = \lambda f$ .A light source such as the sun or a light bulb emits all frequencies within the visible range to produce white light. When white light is incident upon an object, some frequencies are reflected and some are absorbed by the object. The combination of frequencies present in the reflected light determines what we perceive as the color of the object.If low frequencies are predominant in the reflected light, the object is described as red. In this case, the perceived light has the dominant frequency at the red end of the spectrum. The dominant frequency is also called the hue, or simply the color of the light.Brightness is another property, which in the perceived intensity of the light.Intensity in the radiant energy emitted per limit time, per unit solid angle, and per unit projected area of the source.Radiant energy is related to the luminance of the source.The next property in the purity or saturation of the light. Purity describes how washed out or how pure the color of the light appears. Pastels and Pale colors are described as less pure.The term chromaticity is used to refer collectively to the two properties, purity and dominant frequency.

3. **Explain the properties and behavior of any three color models in graphics.**

Color Model is a method for explaining the properties or behavior of color within some particular context. No single color model can explain all aspects of color, so we make use of different models to help describe the different perceived characteristics of color.

XYZ Color

The set of primaries is generally referred to as the XYZ or (X,Y,Z) color model

where X,Y and Z represent vectors in a 3D, additive color space. Any color Cλ is expressed as

$$C_\lambda = X\mathbf{X} + Y\mathbf{Y} + Z\mathbf{Z} \text{-------------} \qquad (1)$$

Where X,Y and Z designates the amounts of the standard primaries needed

to match Cλ.It is convenient to normalize the amount in equation (1) against luminance (X+ Y+ Z). Normalized amounts are calculated as,

$$x = X/(X+Y+Z), \quad y = Y/(X+Y+Z), \quad z = Z/(X+Y+Z)$$

with $x + y + z = 1$

Any color can be represented with just the x and y amounts. The parameters x and y are called the chromaticity values because they depend only on hue and purity.

If we specify colors only with x and y, we cannot obtain the amounts X, Y and Z. so, a complete description of a color in given with the 3 values x, y and Y.

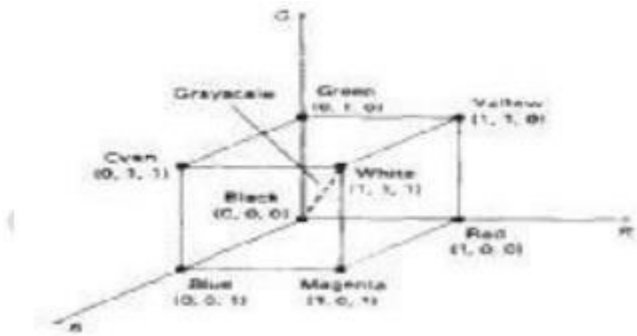
$$X = (x/y)Y, \qquad Z = (z/y)Y \text{ ,Where } z = 1-x-y.$$

Tones of the color are produced by adding both black and white pigments.

RGB Color Model

Based on the tristimulus theory of version, our eyes perceive color through the stimulation of three visual pigments in the cones on the retina.

These visual pigments have a peak sensitivity at wavelengths of about 630 nm (red), 530 nm (green) and 450 nm (blue).By comparing intensities in a light source, we perceive the color of the light.This is the basis for displaying color output on a video monitor using the 3 color primaries, red, green, and blue referred to as the RGB color model. It is represented in the below figure



Vertices of the cube on the axes represent the primary colors, the remaining vertices represents the complementary color for each of the primary colors. The RGB color scheme is an additive model. (i.e.,) Intensities of the primary colors are added to produce other colors.Each color point within the bounds of the cube can be represented as the triple (R,G,B) where values for R, G and B are assigned in the range from 0 to1.The color Cλ is expressed in RGB component as $C\lambda = R\mathbf{R} + G\mathbf{G} + B\mathbf{B}$

The magenta vertex is obtained by adding red and blue to produce the triple (1,0,1) and white at (1,1,1) in the sum of the red, green and blue vertices.

Shades of gray are represented along the main diagonal of the cube from the origin (black) to the white vertex.

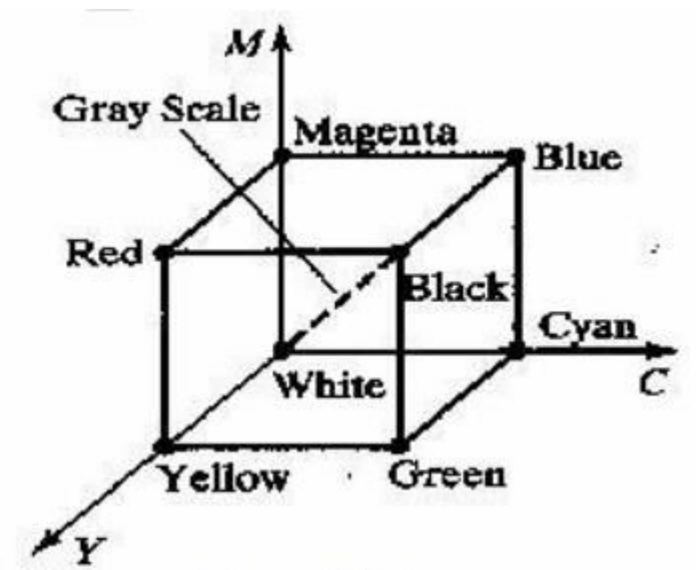
YIQ Color Model

The National Television System Committee (NTSC) color model for forming the composite video signal in the YIQ model.In the YIQ color model, luminance (brightness) information in contained in the Y parameter, chromaticity information (hue and purity) is contained into the I and Q parameters.A combination of red, green and blue intensities are chosen for the Y parameter to yield the standard luminosity curve.Since Y contains the luminance information, black and white TV monitors use only the Y signal.Parameter I contain orange-cyan hue information that provides the flash-tone shading and occupies a bandwidth of 1.5

MHz.Parameter Q carries green-magenta hue information in a bandwidth of about 0.6MHz.

CMY Color Model

A color model defined with the primary colors cyan, magenta, and yellow (CMY) in useful for describing color output to hard copy devices. It is a subtractive color model (i.e.,) cyan can be formed by adding green and blue light. When white light is reflected from cyan-colored ink, the reflected light must have no red component. i.e., red light is absorbed or subtracted by the link.Magenta ink subtracts the green component from incident light and yellow subtracts the blue component.

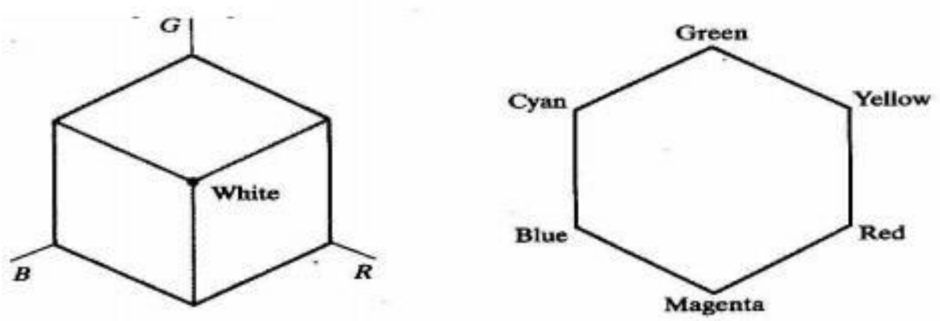


In CMY model, point (1,1,1) represents black because all components of the incident light are subtracted.The origin represents white light.Equal amounts of each of the primary colors produce grays along the main diagonal of the cube.A combination of cyan and magenta ink produces blue light because the red and green components of the incident light are absorbed.The printing process often used with the CMY model generates a color point with a collection of 4 ink dots; one dot is used for each of the primary colors (cyan, magenta and yellow) and one dot in black.The conversion from an RGB representation to a CMY representation is expressed as[ ] [ ] [ ] Where the white is represented in the RGB system as the unit column vector.Similarly the conversion of CMY to RGB representation is expressed as [ ] [ ] [ ]Where black is represented in the

CMY system as the unit column vector.

HSV Color Model

The HSV model uses color descriptions that have a more interactive appeal to a user.Color parameters in this model are hue (H), saturation (S), and value (V). The 3D representation of the HSV model is derived from the RGB cube. The outline of the cube has the hexagon shape.



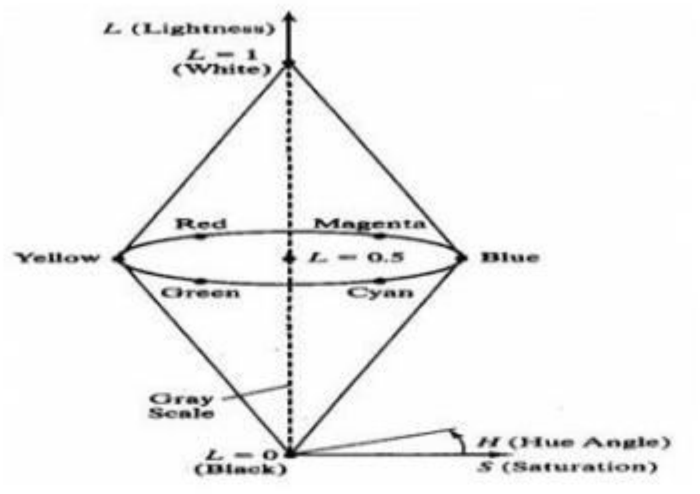
RGB Color Cube
(a)

Color Hexagon
(b)

The boundary of the hexagon represents the various hues, and it is used as the top of the HSV hexcone.In the hexcone, saturation is measured along a horizontal axis, and value is along a vertical axis through the center of the hexcone.Hue is represented as an angle about the vertical axis, ranging from 0^0 at red through 360^0. Vertices of the hexagon are separated by 60^0 intervals. Yellow is at 60^0, green at 120^0 and cyan opposite red at H = 180^0. Complementary colors are 180^0 apart.Saturation S varies from 0 to 1. the maximum purity at S = 1, at S = 0.25, the hue is said to be one quarter pure, at S = 0, we have the gray scale.Value V varies from 0 at the apex to 1 at the top.The apex representation black.At the top of the hexcone, colors have their maximum intensity.When V = 1 and S = 1 we have the „pure" huesWhite is the point at V = 1 and S = 0.

HLS Color Model

HLS model is based on intuitive color parameters used by Tektronix. It has the double cone representation shown in the below figure. The 3 parameters in this model are called Hue (H), lightness (L) and saturation (s).Hue specifies an angle about the vertical axis that locates a chosen hue.



In this model H = θ^0 corresponds to Blue.The remaining colors are specified around the perimeter of the cone in the same order as in the HSV model.Magenta is at 60^0, Red in at 120^0, and cyan in at H = 180^0.The vertical axis is called lightness (L). At L = 0, we have black, and white is at L= 1 Gray scale in along the L axis and the “purehues” on the L = 0.5 plane.Saturation parameter S specifies relative purity of a color. S varies from 0 to 1 pure hues are those for which S = 1 and L = 0.As S decreases, the hues are said to be less pure.At S= 0, it is said to be gray scale.