Computer Graphics
UNIT – I
Part-A

1. Define Computer Graphics.

- Computer graphics remains one of the most existing and rapidly growing computer fields.
- Computer graphics may be defined as a pictorial representation or graphical representation of objects in a computer.

2. What is meant by scan code?

When a key is pressed on the keyboard, the keyboard controller places a code carry to the key pressed into a part of the memory called as the keyboard buffer. This code is called as the scan code.

3. What is meant by refreshing of the screen?

- Some method is needed for maintaining the picture on the screen. Refreshing of screen is done by keeping the phosphorus glowing to redraw the picture repeatedly.
- By quickly directing the electronic beam back to the same points.

4. Define Random scan/Raster scan displays.

Random scan is a method in which the display is made by the electronic beam which is directed only to the points or part of the screen where the picture is to be drawn.

Raster scan system is a scanning technique in which the electrons sweep from top to bottom and from left to right. The intensity is turned on or off to light and un light the pixel.

5. List out the merits and demerits of Penetration techniques.

The merits and demerits of the Penetration techniques are as follows

- It is an inexpensive technique
- It has only four colors
- The quality of the picture is not good when it is compared to other techniques
- It can display color scans in monitors
- Poor limitation etc.

6. List out the merits and demerits of DVST.

The merits and demerits of direct view storage tubes [DVST] are as follows

- It has a flat screen
- Refreshing of screen is not required
- Selective or part erasing of screen is not possible
- It has poor contrast
- Performance is inferior to the refresh CRT.

7. What do you mean by emissive and non-emissive displays?

The emissive display converts electrical energy into light energy. The plasma panels, thin film electroluminescent displays are the examples.

The Non emissive are optical effects to convert the sunlight or light from any other source to graphic form. Liquid crystal display is an example.

8. List out the merits and demerits of Plasma panel display.

Merits

• Refreshing is not required

• Produce a very steady image free of Flicker

• Less bulky than a CRT.

Demerits

• Poor resolution

• It requires complex addressing and wiring

• It is costlier than CRT.

9. What is persistence?

The time it takes the emitted light from the screen to decay one tenth of its original intensity is called as persistence.

10. What is resolution?

The maximum number of points that can be displayed without an overlap on a CRT is called as resolution.

11. What is Aspect ratio?

- The ratio of vertical points to the horizontal points necessary to produce length of lines in both directions of the screen is called the Aspect ratio.
- Usually the aspect ratio is ¾.

12. What is the difference between impact and non-impact printers?

Impact printer press formed character faces against an inked ribbon on to the paper. A line printer and dot-matrix printer are examples.

Non-impact printer and plotters use Laser techniques, inkjet sprays, Xerographic process, electrostatic methods
and electro thermal methods to get images onto the papers. Examples are: Inkjet/Laser printers.

13. What are the features of Inkjet printers?

- They can print 2 to 4 pages/minutes.
- Resolution is about 360d.p.i. Therefore better print quality is achieved.
- The operating cost is very low.
- The only part that requires replacement is ink cartridge.
- 4 colors cyane, yellow, majenta, black are available.

14. What are the advantages of laser printer?

- High speed, precision and economy.
- Cheap to maintain.
- Quality printers.
- Lasts for longer time.
- Toner power is very cheap.

15. Define pixel.

Pixel is shortened forms of picture element. Each screen point is referred to as pixel or pel.

16. What is frame buffer?

Picture definition is stored in a memory area called frame buffer or refresh buffer.

17. What is bitmap and what is pixmap?

The frame buffer used in the black and white system is known as bitmap which take one bit per pixel. For systems with multiple bits per pixel, the frame buffer is often referred to as a pixmap.

18. What do you mean by scan conversion?

A major task of the display processor is digitizing a picture definition given in an application program into a set of pixel-intensity values for storage in the frame buffer. This digitization process is called scan conversion.

19. What is an output primitive?

Graphics programming packages provide function to describe a scene in terms of these basic geometric structures, referred to as output primitives.

Part B&C

1. Explain the Bresenham‘s line drawing algorithm.

BRESENHAM’S LINE ALGORITHM

1. Input the two line endpoints and store the left end point in (x0,y0)
2. load (x0,y0) into frame buffer, ie. Plot the first point.
3. Calculate the constants Δx, Δy, 2Δy and obtain the starting value for the decision parameter as P0 = 2Δy-Δx
4. At each xk along the line, starting at k=0 perform the following test

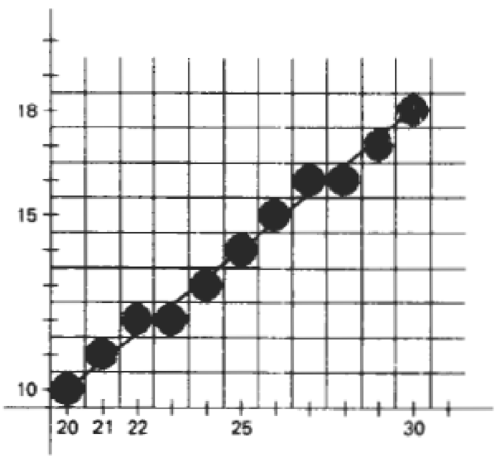
If Pk< 0, the next point to plot is (xk+1,yk) and Pk+1 = Pk+ 2Δy

Otherwise, the next point to plot is (xk+1,yk+1) and Pk+1 = Pk+ 2Δy - 2Δx 5. Perform step4 Δx times.

Implementation of Bresenham Line drawing Algorithm

```
voidlineBres (int xa,intya,intxb, int yb)
{
int dx = abs( xa – xb) , dy = abs (ya - yb);
int p = 2 * dy – dx;
inttwoDy = 2 * dy, twoDyDx = 2 *(dy - dx);
int x , y, xEnd; /* Determine which point to use as start, which as end * /
if (xa> x b )
{
x = xb;
y = yb;
xEnd = xa;
}
else
{
x = xa;
y = ya;
xEnd = xb;
}
setPixel(x,y);
while(x<xEnd)
{
x++;
if (p<0) p+=twoDy;
```

```
else
{
y++;
p+=twoDyDx;
}
setPixel(x,y);
}
}
```



Advantages

1. Algorithm is Fast
2. Uses only integer calculations

Disadvantages: It is meant only for basic line drawing

2.Explain Line drawing algorithm. DIGITAL DIFFERENTIAL ANALYZER (DDA) ALGORTIHM

Algorithm

```
#define ROUND(a) ((int)(a+0.5))
voidlineDDA (int xa, int ya, int xb, int yb)
{
int dx = xb - xa, dy = yb - ya, steps, k;
floatxIncrement, yIncrement, x = xa, y = ya;
if (abs (dx) > abs (dy) steps = abs (dx) ;
else steps = abs dy);
xIncrement = dx / (float) steps;
yIncrement = dy / (float) steps
```

```
setpixel (ROUND(x), ROUND(y) ) :
for (k=0; k<steps; k++)
{
x += xIncrement;
y += yIncrement;
setpixel (ROUND(x), ROUND(y));
}
}
```

Algorithm Description:

Step 1 :Accept Input as two endpoint pixel positions

Step 2: Horizontal and vertical differences between the endpoint positions *are* assigned to parameters dx and dy (Calculate dx=xb-xa and dy=yb-ya).

Step 3: The difference with the greater magnitude determines the value of parameter steps.

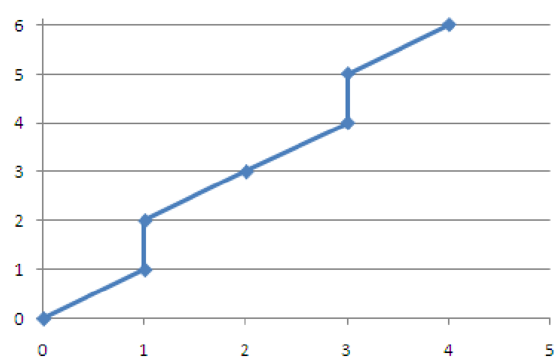
Step 4 : Starting with pixel position (xa, ya), determine the offset needed at each step to generate the next pixel position along the line path.

Step 5: loop the following process for steps number of times

a. Use a unit of increment or decrement in the x and y direction

b. if xa is less than xb the values of increment in the x and y directions are 1 and m

c. if xa is greater than xb then the decrements -1 and – m are used.



Advantages of DDA Algorithm

1. It is the simplest algorithm
2. It is a is a **faster method** for calculating pixel positions

Disadvantages of DDA Algorithm

1. Floating point arithmetic in DDA algorithm is still time-consuming
2. End point accuracy is poor

3. Explain refresh cathode ray tube.

The primary output device is a video monitor. The operation of most video monitors is based on the standard cathode-ray tube(CRT).

REFRESH CATHODE-RAY TUBES

1).A beam of Cathode rays emitted by an Electron gun moves through deflection systems.

2).So these deflection systems which direct the beam towards a specified position on the Screen.

3).This Screen is Phosphor coated, and this Phosphor emits a spot of light at each position where it is contacted by the Electron beam

4).To maintain the screen picture we need some process, as the light emitted by the phosphor fades with very high speed.

5).That method we require is "To keep up the phosphor glowing is to draw up again (redraw) the picture repeatedly by quickly directing this electron beam back on to the same points which were resulted in first time path. This kind of Display is called "Refresh CRT".

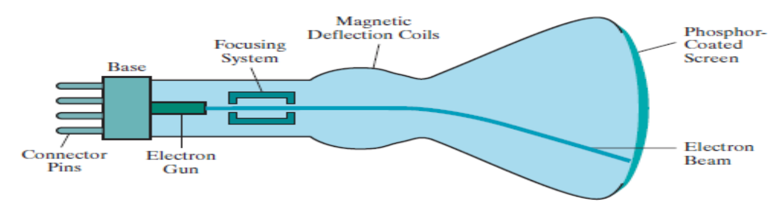


FIGURE 2–2 Basic design of a magnetic-deflection CRT.

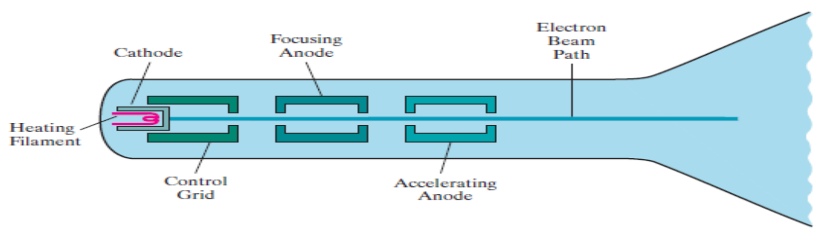


FIGURE 2–3 Operation of an electron gun with an accelerating anode.

Working:

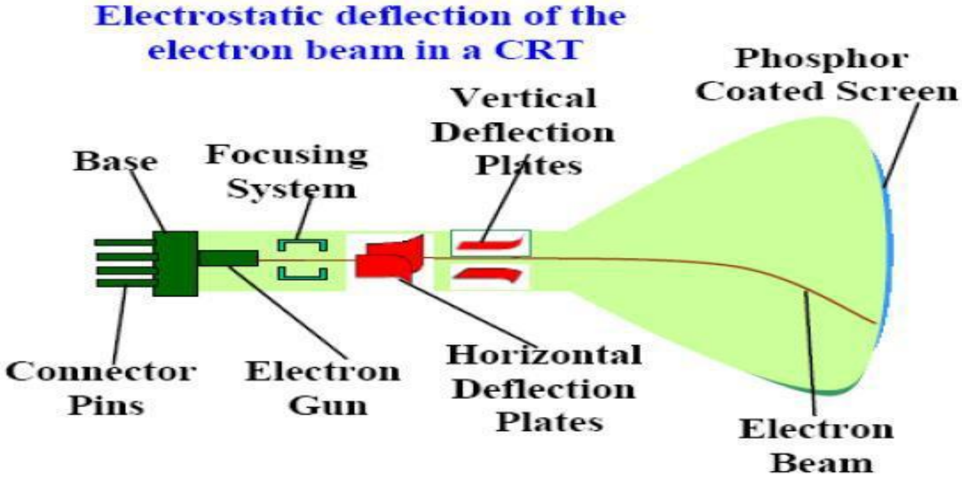
Electron Gun Components:

i).Heated Metal Cathode

ii).Control Grid

- The electron beam consists of electrons which are negatively charged.
- The control grid is a cylindrical device which is also negatively charged.

- It is a high negative voltage which is applied to the control grid.
- Intensity of the electrons beam is controlled by setting voltage levels on the control grid, which is a metal cylinder that fits over the cathode.
- The accelerating voltage can be generated it positively charged metal coating on the inside of the CRT envelop near the phosphor screen .
- The focusing system in a CRT is needed to force the electron beam to converge into a small spot as it strikes the phosphor.



There are two pairs of coils used, with the coils in each pair mounted on opposite sides of the neck of the CRT envelope.

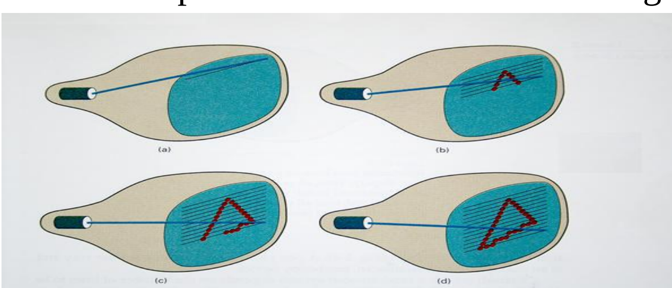
- One pair of plates is mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control the horizontal deflection.
- The maximum number of points that can be displayed without overlap on a CRT id referred to as the resolution.
- Spot size is also depends on intensity.

4)RASTER-SCAN DISPLAYS

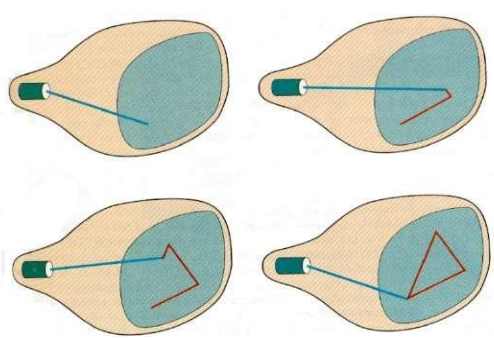
- The Raster-scan display is based on the television technology.
- In a raster- scan system, the electron beam is swept across the screen, one row at a time from top to bottom.
- As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.

- Picture definition is stored in 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** or **picture element**.

- 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.
- At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line.
- The return to the left of the screen, after refreshing each scan line, is called the **horizontal retrace** of the electron beam.
- And at the end of each frame, the electron beam returns (**vertical retrace**)to the top left corner of the screen to begin the next frame



5)RANDOM-SCAN DISPLAYS



- A CRT has the electron beam directed only on 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.
- Refresh rate on a random-scan system depends on the number of lines to be displayed .
- Picture definition is now stored as a set of line-drawing commands in an area of memory referred to as the refresh display file.
- Sometimes the **refresh display file** is called the **display list, display program,** or simply the **refresh buffer**.
- To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn. After all line- drawing commands have been processed

Unit-II
Part A

1. What is Transformation?

Transformation is the process of introducing changes in the shape size and orientation of the object using scaling rotation reflection shearing & translation etc.

2.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

3. What is rotation?

A 2-D rotation is done by repositioning the coordinates along a circular path, in

X = rcos (q + f) and Y = r sin (q + f).

4. 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.

5.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.

6. What is reflection?

The reflection is actually the transformation that produces a mirror image of an object.

7.Define viewing transformation.

- The mapping of a part of world coordinate scene to device coordinates are called viewing transformation.
- Two dimensional viewing transformation is simply referred to as window to viewport transformation or the windowing transformation.

9.What is a Line cap?

Line caps can be used to adjust the shape of the line ends to give a better appearance. There are three types of line caps. Butt cap which has a square end, round cap which has a semi circle end, projecting square cap which has one half of the line width beyond the specified end points.

10.Define clipping.

Any procedure that identifies those portions of a picture that are either inside or outside of a Specified region of space is referred to as a clipping algorithm or clipping. The region against which an object is to be clipped is called as the clip window

11.What are the basic transformations?

Translation : Translation is applied to an object by repositioning it along a straight line path from one coordinate location to another. x1=x+Tx y1=y+Ty (Tx,Ty) – translation vector or shift vector

Rotation: A two dimensional rotation is applied to an object by repositioning it along a circular path in the xy plane.

Scaling: A scaling transformation alters the size of an object .

x1=x.Sx y1=y.SySx and Sy are scaling factors.

12.Define clipping? And types of clipping.

Clipping is the method of cutting a graphics display to neatly fit a predefined graphics region or the view port.

- Point clipping
- Line clipping

- Area clipping
- Curve clipping
- Text clipping

Part B&C

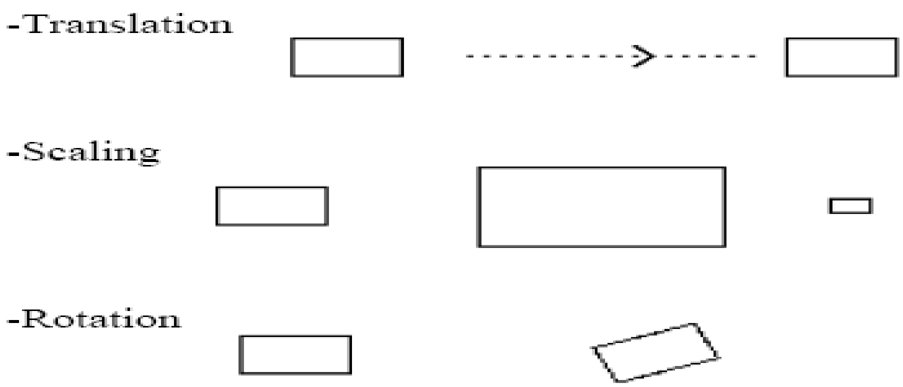
1.Write a detailed note on the basic two dimensional transformations

BASIC TWO-DIMENSIONAL GEOMETRIC TRANSFORMATIONS

Operations that are applied to the geometric description of an object to change its position, orientation, or size are called ***geometric transformations***. Geometric transformations can be used to describe how objects might move around in a scene during an animation sequence or simply to view them from another angle

Geometric transformations

1. Translation
2. Rotation
3. Scaling



Translation

We translate a 2D point by adding translation distances, tx and ty, to the original coordinate position (x,y):

x' = x + tx, y' = y + ty

Alternatively, translation can also be specified by the following transformation matrix:

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

Then we can rewrite the formula as:

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Two-Dimensional Rotation

1. We generate a rotation transformation of an object by specifying a rotation axis and a rotation angle.
2. A two-dimensional rotation of an object is obtained by repositioning the object along a circular path in the xy plane.
3. Parameters for the two-dimensional rotation are

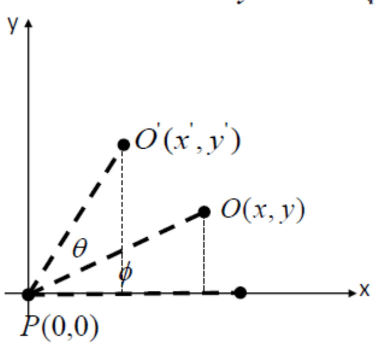
–The rotation angle θ

–A position (x,y) – rotation point (pivot point)

The two-dimensional rotation

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

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



Polar coordinate system

$$x = r\cos\phi$$

$$y = r\sin\phi$$

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

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

We can write the rotation equation in the matrix form a:

P’=R.P

The rotation matrix is

R= $\begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}$

The transpose matrix for the equation is

$P'^T = (R.P)^T = P^T.R^T$

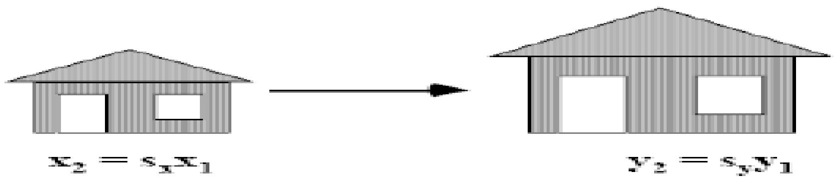
Two-Dimensional Scaling

1. To alter the size of an object, we apply a scaling transformation.

2. A simple two-dimensional scaling operation is performed by multiplying object positions (x,y) by scaling factors sx and sy to produce the transformed coordinates (x‘,y‘).

3. Any positive values can be assigned to the scaling factors.

- Values less than 1 reduce the size of object;
- Values greater than 1 produce enlargements.
- Uniform scaling – scaling values have the same value
- Differential scaling – unequal of the scaling factor



$$x = x \cdot s_x$$

$$y' = y \cdot s_y$$

$$\Downarrow$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$P' = S \bullet P$$

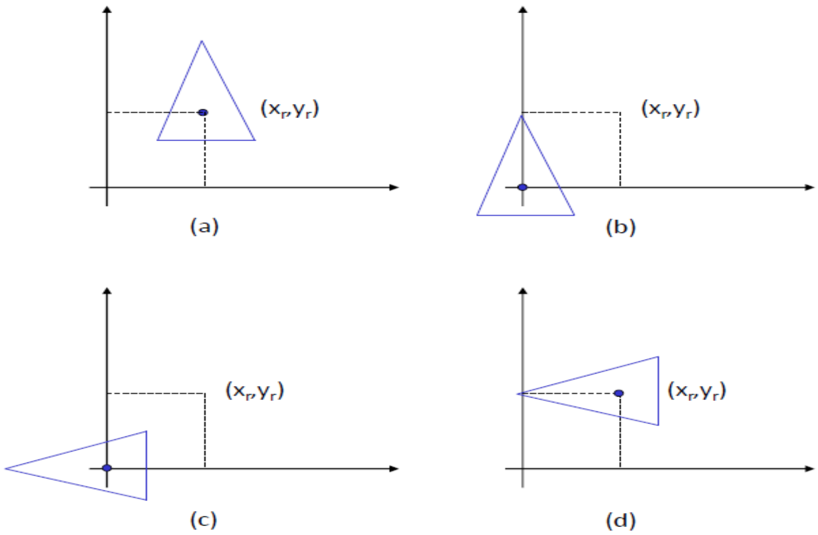
2. **General Two-dimensional Pivot-Point Rotation**

1. A transformation sequence for rotating an object about a specified pivot point using the rotation matrix **R**(θ).

2. Translate the object so that the pivot-point position is moved to the coordinate origin.

3. Rotate the object about the coordinate origin.

4. Translate the object so that the pivot point is returned to its original position.



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

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

$$T(x_r, y_r) \cdot R(\theta) \cdot T(-x_r, -y_r) = R(x_r, y_r, \theta)$$

Unit-III

Part-A

1. **What is Transformation?**

   Transformation is the process of introducing changes in the shape size and orientation of the object using scaling rotation reflection shearing & translation etc.

2. **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

3. **What is rotation?**

A 2-D rotation is done by repositioning the coordinates along a circular path, in X = rcos (q + f) and Y = r sin (q + f).

4. **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.

5. **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.

6. **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.

7. **Distinguish between window port & view port**

A portion of a picture that is to be displayed by a window is known as window port. The display area of the part selected or the form in which the selected part is viewed is known as view port.

8. Define clipping? And types of clipping.

Clipping is the method of cutting a graphics display to neatly fit a predefined graphics region or the view port.

- Point clipping
- Line clipping
- Area clipping
- Curve clipping
- Text clipping

9. What is fixed point scaling?

The location of a scaled object can be controlled by a position called the fixed point that is to remain unchanged after the scaling transformation.

10. List out the various Text clipping.

- All-or-none string clipping -if all of the string is inside a clip window, keep it otherwise discards.
- All-or-none character clipping – discard only those characters that are not completely inside the window.

- Any character that either overlaps or is outside a window boundary is clipped.

11. What is the use of clipping?

Clipping in computer graphics is to remove objects, lines or line segments that are outside the viewing volume.

12. Define viewing transformation.

The mapping of a part of world coordinate scene to device coordinates are called viewing transformation. Two dimensional viewing transformation is simply referred to as window to viewport transformation or the windowing transformation.

Part-B&C

1. **Explain Cohen-Sutherland Line clipping algorithm.**

Cohen-Sutherland Line Clipping :

1. Region Code Creation

–Region Code

•Bit 1: left

•Bit 2: right

•Bit 3: below

•Bit 4: above

–Calculate differences between endpoint coordinates and clipping boundaries

–Use the resultant sign bit of each difference calculation to set the corresponding value in the region code

1. Outside Line Removal Test

–A method that can be used to test lines total clipping is to perform the logical and operation with both region codes

–Not 0000

2. Completely outside the clipping region!!

3. Lines that cannot be identified as completely inside or outside a clip window by this test.
4. Calculate Intersection Point
– Using the slope-intercept form
– Vertical Boundary, $y = y1 + m (x – x1)$
– Horizontal Boundary

2. **Explain the various clipping operations.**

CLIPPING OPERATIONS

Any procedure that identifies those portions of a picture that is either inside or outside of a
specified region of space

1. Applied in World Coordinates
2. Adapting Primitive Types

–Point
–Line
–Area (or Polygons)
–Curve, Text

Point Clipping:

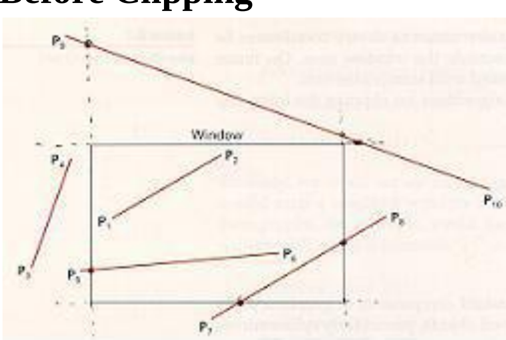
1. Assuming that the clip window is a rectangle in standard position
2. Saving a point P=(x, y) for display

xwmin <=x<=xwmax
ywmin <=y<=ywmax

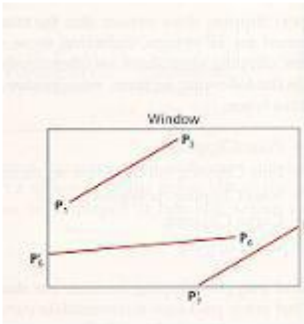
3. Appling Fields - Particles (explosion, sea foam)

Line Clipping:

Before Clipping



After Clipping



1. Parametric representation of Line segment with endpoints (x1, y1) and (x2, y2)
x = x1 + u(x2-x1)
y = y1 + u(y2-y1) ; 0<=u<=1
2. Exterior of the window
– Intersection with outside the range u
3. Interior of the window
– Intersection with inside the range u

Unit-IV

Part-A

1.What are the various 3D transformations?

The various 3D transformations are translation, reflection, scaling, rotation and shearing.

2.What is shear transformation?

Shearing transformations can be used to modify object shapes. They are also used in 3D
viewing for obtaining general projection transformation. A z-axis 3D shear:

$$SHZ = \begin{matrix} 1 & 0 & a & 0 \\ 0 & 1 & b & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{matrix}$$

Parameters a and b can be assigned any real value.

3.Define viewing.

Viewing in 3D have more parameters to select when specifying how a 3D scene is to be mapped to a display device. The scene description must be processed through the viewing coordinate transformation and projection routines that transform the 3D viewing coordinate into 2D device coordinates.

4.What are the two types of projections?

Parallel projection: coordinate positions are transformed to the view plane along parallel lines.

Perspective projection: object positions are transformed to the view plane along lines that converge to a point called projection reference point.

5.Differentiate parallel projection from perspective projection.

Parallel Projection	**Perspective Projection**
In parallel projection, coordinate positions are transformed to the view plane along parallel lines	In perspective projection, object positions are transformed to the view plane along lines that converge to a point called projection reference point or center of projection
Preserves the relative proportions of objects	Produce realistic views but does not preserve relative proportions
Used in drafting to produce scale drawings of 3Dobjects.	Projections of distant objects are smaller than the projections of objects of the same size that are closer to the projection plane

6. Differentiate oblique and orthographic parallel projections.

Orthographic Parallel Projection	**Oblique Parallel projection**
Projection is perpendicular to the view plane.	Projection is not perpendicular to the view Plane
Used to produce front, side and top views of Object called as elevations	An oblique projection vector is specified with two angles.

.**7. What are the two types of parallel projection?**

Orthographic parallel projection: projection is perpendicular to the view plane.

Oblique parallel projection: projection is not perpendicular to the view plane.

8.What is axonometric projection?

Orthogonal projections that display more than one face of an object are axonometric projection.

9.What is isometric projection?

Isometric projection is obtained by aligning the projection plane so that it intersects each coordinate axis in which the object is defined at the same distance from the origin.

10. **Mention some surface detection methods.**

Back-face detection, depth-buffer method, A-buffer method, scan-line method, depth-sorting method, BSP-tree method, area subdivision, octree method, ray casting.

Part-B&c

1.Explain in detail about various methods of 3D Concepts

THREE DIMENSIONAL DISPLAY METHODS

To obtain display of a three-dimensional scene that has been modeled in world coordinates. we must first set up a coordinate reference for the "camera".

PARALLEL PROJECTION

In a parallel projection, parallel lines in the world-coordinate scene projected into parallel lines on the two-dimensional display plane.

Perspective Projection

Another method for generating a view of a three-dimensional scene is to project points to the display plane along converging paths.

This causes objects farther from the viewing position to be displayed smaller than objects of the same size that are nearer to the viewing position.

DEPTH CUEING

A simple method for indicating depth with wireframe displays is to vary the intensity of objects according to their distance from the viewing position.

The viewing position are displayed with the highest intensities, and lines farther away are displayed with decreasing intensities.

Visible Line and Surface Identification

The simplest method is to highlight the visible lines or to display them in a different color.

Another technique, commonly used for engineering drawings, is to display the non visible lines as dashed lines.

Another approach is to simply remove the non visible lines

Surface Rendering

Added realism is attained in displays by setting the surface intensity of objects according to the lighting conditions in the scene and according to assigned surface characteristics.

Lighting specifications include the intensity and positions of light sources and the general background illumination required for a scene.

Exploded and Cutaway View

Exploded and cutaway views of such objects can then be used to show the internal structure and relationship of the object Parts

Three-Dimensional and Stereoscopic View

Three-dimensional views can be obtained by reflecting a raster image from a vibrating flexible mirror. The vibrations of the mirror are synchronized with the display of the scene on the CRT.

Stereoscopic View

As the mirror vibrates, the focal length varies so that each point in the scene is projected to a position corresponding to its depth.

2. Explain all 3D transformations.

Three Dimensional Transformations

Methods for geometric transformations and object modeling in 3D are extended from 2D methods by including the considerations for the z coordinate.

Basic geometric transformations are: Translation, Rotation, Scaling

Basic Transformations

Translation

We translate a 3D point by adding translation distances, tx, ty, and tz, to the original coordinate

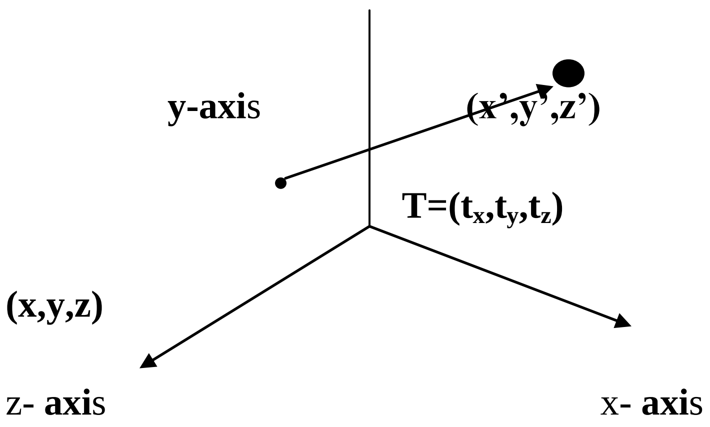
position (x,y,z): x' = x + tx, y' = y + ty, z' = z + tz

Alternatively, translation can also be specified by the transformation matrix in the following formula:

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

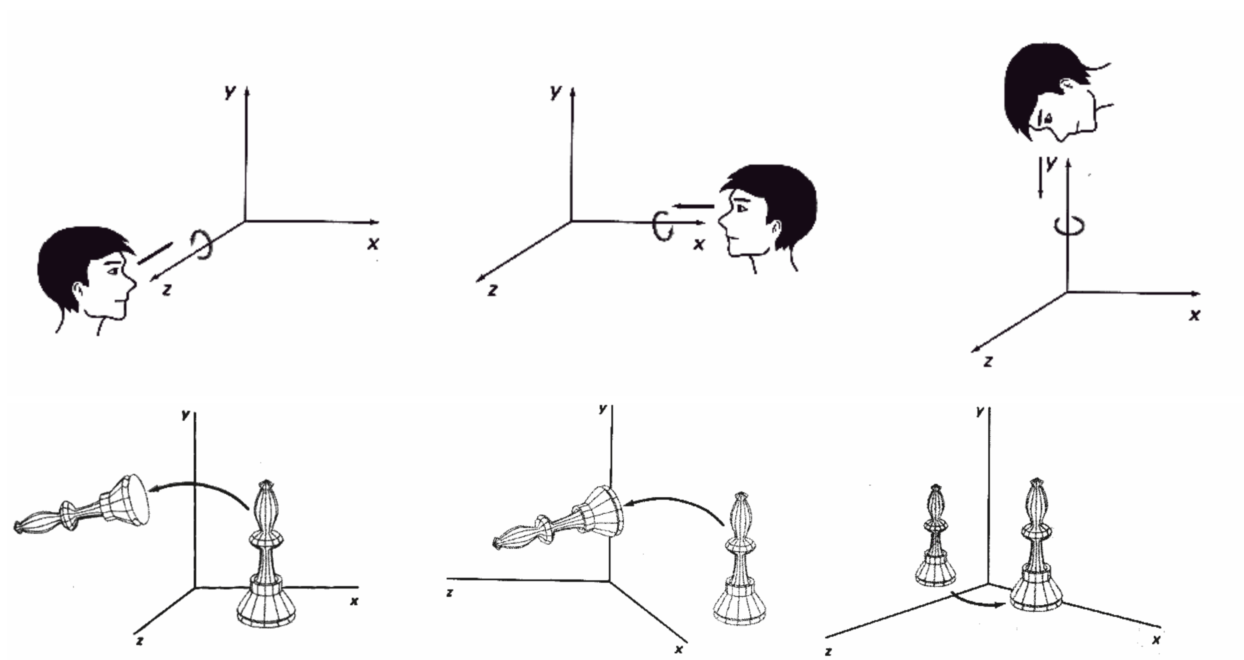
P'=T.P

$x' = x + t_x$, $y' = y + t_y$, $z' = z + t_z$



Coordinate-Axes Rotations

A 3D rotation can be specified around any line in space. The easiest rotation axes to handle are the
coordinate axes.



Z-axis rotation:

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

x' = x cos θ- y sin θ
y' = x sin θ + y cos θ
z' = z

P'=R$_z$(θ).P

X-axis rotation

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & & 0 & 0 \\ & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

y' = y cos θ - z sin θ
z' = y sin θ + z cos θ
x' = x

P'=R$_x$(θ).P

Y-axis rotation:

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & & \sin\theta & 0 \\ -\sin\theta & & \cos\theta & 0 \\ 0 & & & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

z' = z cos θ - x sin θ
x' = z sin θ + x cos θ
y' = y

P'=R_y(θ).P

Scaling

In 3D scaling operation, three coordinates are used. Let us assume that the original coordinates are (X, Y, Z), scaling factors are (SX,SY,Sz)(SX,SY,Sz) respectively, and the produced coordinates are (X', Y', Z'). This can be mathematically represented as shown below −

$$\begin{pmatrix} X' \\ Y' \\ Z' \\ 1 \end{pmatrix} = \begin{pmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} . \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$

P'=S.P

Unit-V

1.Discuss the various surface detection methods in detail.

Back face detection

A point (x,y,z) is inside a polygon surface with plane parameters A,B,C and D if Ax+By+Cz+D < 0When an inside point is along the line of sight to the surface , the polygon must be a back-face

Conditions for back face: A polygon is a back-face if V.N > 0

Depth buffer method

Steps

Initialize the depth buffer and refresh buffer so that for all the buffer positions (x,y) depth(x,y) = 0 , refresh(x,y) = I backgnd

For each position on each polygon surface listed on the polygon table calculate the depth value and compare the depth value to the previously stored values in the depth buffer to determine visibility

Let the calculated depth be Z for each position (x,y)

If Z > depth(x,y) , then set) depth(x,y) = Z , refresh(x,y) = Isurf (x,y)

Scan-line method-concept-example-diagram

Extension of scan line algorithm for filling polygon interiors

All polygon surfaces intersecting the scan lines are examined

Depth calculations are made for each overlapping surface across every scan line to determine the nearest surface to the view plane After the visible surface is determined the intensity value for the position is entered into the refresh buffer

Depth-sorting method

Steps:

Surfaces are ordered according to the largest Z value

Surface S with greatest depth is compared with other surfaces to determine whether there are any overlaps in depth If no depth overlap occurs , S is scan converted This process is repeated for the next surface as long as no overlap occurs

If depth overlaps occurred additional comparisons are used to determine whether reordering of surfaces are needed or not

Ray casting method

- it is a variation of depth buffer method
- process pixels one at a time and calculate depths for all surfaces along the projection path to that pixel

2.Explain in detail about depth buffer method and A-buffer method for visible surface detection.

Depth buffer method

Steps

1. Initialize the depth buffer and refresh buffer so that for all the buffer positions (x,y) depth(x,y) = 0 , refresh(x,y) = I backgnd
2. For each position on each polygon surface listed on the polygon table calculate the depth value and compare the depth vaslue to the previously stored values in the depth buffer to determine visibility

3.Let the calculated depth be Z for each position (x,y)

If Z > depth(x,y) , then set) depth(x,y) = Z , refresh(x,y) = Isurf (x,y)