Unit I
INTRODUCTION
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 the pictorial representation or graphical representation of objects in a computer

2.Write short notes on video controller.
Video controller is used to control the operation of the display device.A fixed area of the system is reserved for the frame buffer and the video controller is given direct access to the frame buffer memory 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 coprocessor sand accelerators to implement various graphics operations.

3.Write notes on Graphics controller?
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

4.List out a few attributes of output primitives?
Attributes are the properties of the output primitives; that is, an attribute describes how a particular primitive is to be displayed. They include intensity and color specifications, line styles, text styles, and area-filling patterns. Functions within this category can be usedto set attributes for an individual primitive class or for groups of output primitives.

5.What is vertical retrace of the electron beam?
In raster scan display at the end of one frame the electron beam returns to the left top corner of the screen to start the next frame is called vertical retrace of the electron beam.

6. Define persistence, resolution and aspect ratio.
Persistence is defined as the time it takes the emitted light from the screen to decay to one tenth of its original intensity.The maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution.Aspect ratio is the ratio of the vertical points to horizontal points necessary to produce equal length lines in both directions on the screen.

7.What is the major difference between symmetrical DDA and simple DDA

Simple DDA	**Symmetric DDA**
In simple DDA, $m=\Delta x/e\Delta y$ is transformed to $m=e\Delta x/e\Delta y$ where e, call it the increment factor, is a positive real number	In symmetric DDA, *e* is chosen such that *though* both the co-ordinates of the resultant points has tobe rounded off, it can be done so very efficiently,thus quickly.
*e*is chosen as $1/\max(\lvert\Delta x\rvert,\lvert\Delta y\rvert)$ such that one of the coordinate is integral and only the other coordinate has to be rounded. i.e. P(i+1) = P(i)+($1,\mathrm{Round}(e*\Delta y)$)) here one coordinate is being incremented by 1 and the other by $e*\Delta y$	*e* is chosen as 1/2^n where 2^(n-1) <= $\max(\lvert\Delta x\rvert,\lvert\Delta y\rvert)$ < 2^n. In other words the length of the line is taken to be 2^n aligned. The increments for the two coordinates are $e*\Delta x$ and $e*\Delta y$.

8. What is horizontal and vertical retrace?
The return to the left of the screen after refreshing each scan line is called as the horizontal retrace.Vertical retrace: At the end of each frame the electron beam returns to the top left corner of the screen to the beginning the next frame.

9. What is interlaced refresh?
Each frame is refreshed using two passes. In the first pass, the beam sweeps across every other scan linefrom top to bottom. Then after the vertical retrace, the beam traces out the remaining scan lines.

10. What is a raster scan system?
In a raster scan system the electron beam is swept across the screen, one row at a time 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 information is stored in a memory area called refresh buffer or frame buffer. Most suited for scenes with subtle shading and color patterns.

11. What is a random scan system?

In 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. This display is also called as vector displays. Picture definition is stored as asset of line drawing commands in a memory referred to the refresh display file or display list or display program.

12. Write down the attributes of characters.
The appearance of displayed characters 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. The choice of font gives a particular design style. Characters can also be displayed as underlined, in boldface, in italics and in outline or shadow styles.
13. What is scan conversion and what is a cell array?
Digitizing a picture definition given in an application program into a set of pixel intensity values for storage in the frame buffer by the display processor is called scan conversion.The cell array is a primitive that allow users to display an arbitrary shape defined as a two dimensional grid pattern.
14. Write down any two line attributes. (AU NOV/DEC 2011)
The basic attributes of a straight line segment are its:

- Type: solid, dashed and dotted lines.
- Width: the thickness of the line is specified.
- Color: a color index is included to provide color or intensity properties.

15. What are line caps?
The shape of the line ends are adjusted to give a better appearance by adding line caps.
Butt cap: obtained by adjusting the end positions of the component parallel lines so that the thickline is displayed with square ends that is perpendicular to the line path.
Round cap: obtained by adding a filled semicircle to each butt cap.
Projecting square cap: extend the line and add butt caps that are positioned one-half of the linewidth beyond the specified endpoints.
16. What are different methods of smoothly joining two line segments?
Miter joins: Accomplished by extending the outer boundaries of each of the two lines until theymeet.
Round join: produced by capping the connection between the two segments with a circularboundary whose diameter is equal to the line width.
Bevel join: generated by displaying the line segments with butt caps and filling in the triangulargap where the segments meet.
17. Write down the attributes of characters.(AU MAY/JUNE 2012 IT)
The appearance of displayed characters 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. The choice of font gives a particular design style. Characters can also be displayed as underlined, in boldface, in italics and in outline or shadow styles.
18. Briefly explain about the unbundled and bundled attributes.
Unbundled attributes: how exactly the primitive is to be displayed is determined by its attribute setting.These attributes are meant to be used with an output device capable of displaying primitives the wayspecified.
Bundled attributes: when several kinds of output devices are available at a graphics installation, it is convenient for a user to be able to say how attributes are to be interpreted on different o/p devices. This is accomplished by setting up tables for each output device that lists sets of attribute value that are to be used on that device to display each primitive type. A particular set of attribute values for a primitive on each o/p device is then chosen by specifying the appropriate table index. Attributes specified in this manner is called as bundled attribute.
19. Digitize a line from (10,12) to (15,15) on a raster screen using Bresenham's straight linealgorithm.
The line has a slope of 0.6 with$\Delta x=5$, $\Delta y=3$
The initial decision parameter has the value$P0=2\Delta y-\Delta x=6-5=1$
And the increments for calculating successive decision parameters are$2\Delta y-2\Delta x=6-10=-4$
We plot the point (x0.y0) =(10,12), and determine successive pixel positions along theline path from the decision parameter as

K	p_k	(x_{k+1}, y_{k+1})
0	1	(11, 13)
1	-3	(12, 13)
2	3	(13, 14)
3	-1	(14, 14)
4	5	(15, 15)

20. Define pixel.
Pixel is a shortened form of picture element. Each screen point is referred to as pixel or pel
21. Define aliasing.

Displayed primitives generated by the raster algorithms have a jagged, stair step 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

22. What is antialiasing?

Appearance of displayed raster lines by applying antialiasing methods that compensate for the undersampling process.

Nyquist sampling frequency: to avoid losing information, the sampling frequency to at least twice that ofthehighest frequency occurring in the object. Fs=2*fmax.

23. What is antialiasing by super sampling or post filtering?

This is a technique of sampling object characteristics at a high resolution and displaying results at a lower resolution.

24. What is antialiasing by area sampling or prefiltering?

An alternative to super sampling is to determine pixel intensity by calculating areas of overlap of eachpixel with the objects to be displayed .antialiasing by computing overlaps areas is referred to as areasampling or prefiltering.

25. What is antialiasing by pixel phasing?

Raster objects can be antialiased by shifting the display location of pixel areas. This is applied by "micropositioning" the electron beam in relation to object geometry.

Part B

1. Explain the Bresenham's line drawing algorithm with example. (AU MAY/JUNE 2012 IT)

<u>BRESENHAM'S LINE ALGORITHM</u>

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 xkalong 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);
}
}
```

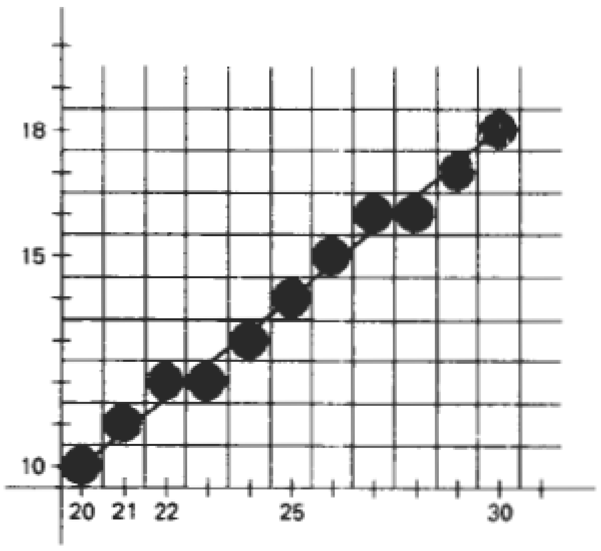
Example : Consider the line with endpoints (20,10) to (30,18)
The line has the slope m= (18-10)/(30-20)=8/10=0.8

$\Delta x = 10 \Delta y=8$
The initial decision parameter has the value $p0 = 2\Delta y- \Delta x = 6$
and the increments for calculating successive decision parameters are
$2\Delta y=16$ $2\Delta y-2 \Delta x= -4$
We plot the initial point (x0,y0) = (20,10) and determine successive pixel positions along the line path from the decision parameter as

TABULATION:

k	**pk**	**(xk+1, yK+1)**
0	6	(21,11)
1	2	(22,12)
2	-2	(23,12)
3	14	(24,13)
4	10	(25,14)
5	6	(26,15)
6	2	(27,16)
7	-2	(28,16)
8	14	(29,17)
9	10	(30,18)

RESULT:



Advantages
1. Algorithm is Fast
2. Uses only integer calculations

Disadvantages It is meant only for basic line drawing

2. Explain the midpoint circle drawing algorithm. Assume 10 cm as the radius and co-ordinate origin as the center of the circle. (AU NOV/DEC 2011)

Given a circle radius r=10
The circle octant in the first quadrant from x=0 to x=y.
The initial value of the decision parameter is

$P_0=1-r=-9$

For the circle centered on the coordinate origin, the initial point is

$(X_0, y0)=(0, 10)$

and initial increment terms for calculating the decision parameters are

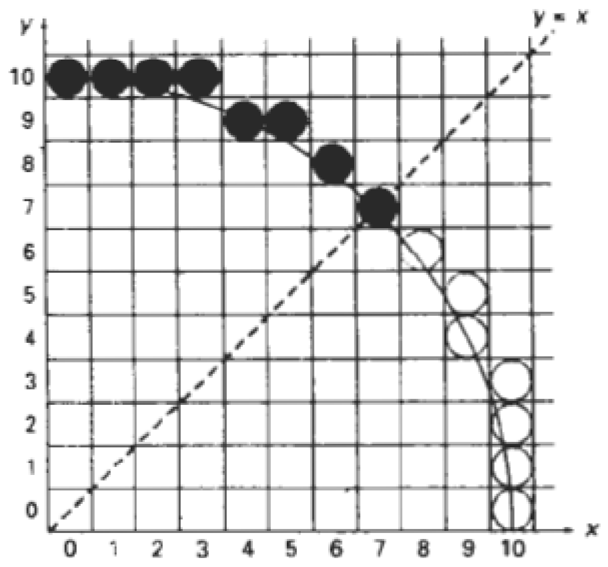
$2x_0=0, 2y_0=20$

Successive midpoint decision parameter values and the corresponding coordinate positions along the circle path are listed in the following table.

TABULATION :

k	**p_k**	**(xk+1, yk-1)**	**$2x_{k+1}$**	**$2y_{k+1}$**
0	-9	(1,10)	2	20
1	-6	(2,10)	4	20
2	-1	(3,10)	6	20
3	6	(4,9)	8	18
4	-3	(5,9)	10	18
5	8	(6,8)	12	16
6	5	(7,7)	14	14

RESULT :



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<u>Implementation of Midpoint Circle Algorithm</u>

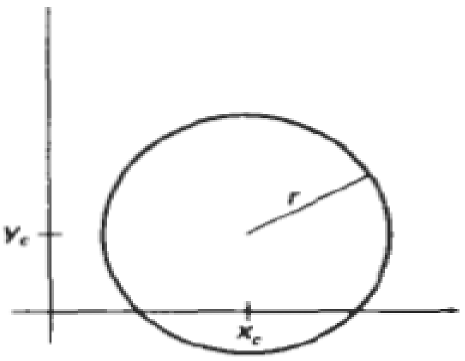
```
voidcircleMidpoint (int xCenter, int yCenter, int radius)
{
int x = 0; int y = radius;
int p = 1 - radius;
voidcirclePlotPoints (int, int, int, int); /* Plot first set of points */
irclePlotPoints (xCenter, yCenter, x, y);
while (x < y)
 {
 x++ ;
if (p < 0) p +=2*x +1;
else
{
y--; p +=2* (x - Y) + 1;
}
circlePlotPoints(xCenter, yCenter, x, y)
}
}
voidcirclePlotPolnts (int xCenter, int yCenter, int x, int y)
```

```
{
setpixel (xCenter + x, yCenter + y ) ;
setpixel (xCenter - x. yCenter + y);
setpixel (xCenter + x, yCenter - y);
setpixel (xCenter - x, yCenter - y ) ;
setpixel (xCenter + y, yCenter + x);
setpixel (xCenter - y , yCenter + x);
setpixel (xCenter t y , yCenter - x);
setpixel (xCenter - y , yCenter - x);
}
```

3. **Explain about Bresenham's circle generating algorithm with example.(AU MAY2012)**

<u>CIRCLE-GENERATING ALGORITHMS</u>

A circle is defined as a set of points that are all the given distance (xc,yc).



$(x – x_c)^2 + (y – y_c)^2 = r^2$

Midpoint circle Algorithm

1. Input radius r and circle center (xc,yc) and obtain the first point on the circumference of the circle centered on the origin as (x0,y0) = (0,r)
2. Calculate the initial value of the decision parameter as P0=(5/4)-r
3. At each xk position, starting at k=0, perform the following test.
 If Pk<0 the next point along the circle centered on (0,0) is (xk+1,yk) and
Pk+1=Pk+2xk+1+1
Otherwise the next point along the circle is (xk+1,yk-1) and
Pk+1=Pk+2xk+1+1-2 yk+1 Where 2xk+1=2xk+2 and 2yk+1=2yk-2
4. Determine symmetry points in the other seven octants.
5. Move each calculated pixel position (x,y) onto the circular path centered at (xc,yc) and plot the coordinate values. x=x+xc y=y+yc 6. Repeat step 3 through 5 until x>=y.

4. Explain in detail about Bresenham's ellipse generating algorithm. Give example.

<u>BRESENHAM'S ELLIPSE GENERATING ALGORITHM</u>

Mid point Ellipse Algorithm

1. Input rx,ry and ellipse center (xc,yc) and obtain the first point on an ellipse centered on the origin as (x0,y0) = (0,ry)
2. Calculate the initial value of the decision parameter in region 1 as
P10=ry2-rx2ry +(1/4)rx2
At each xk position in region1 starting at k=0 perform the following test.
3. If P1k<0, the next point along the ellipse centered on (0,0) is (xk+1, yk) and
p1k+1 = p1k +2 ry2xk +1 + ry2
4. Otherwise the next point along the ellipse is (xk+1, yk-1) and
p1k+1 = p1k +2 ry2xk +1 - 2rx2 yk+1 + ry2
with 2 ry2xk +1 = 2 ry2xk + 2ry2 2 rx2yk +1 = 2 rx2yk + 2rx2
And continue until 2ry2 x>=2rx2 y
5. Calculate the initial value of the decision parameter in region 2 using the last point (x0,y0) is the last position calculated in region 1.
p20 = ry2(x0+1/2)2+rx2(yo-1)2 – rx2ry2

6. At each position yk in region 2, starting at k=0 perform the following test, If p2k>0 the next point along the ellipse centered on (0,0) is (xk,yk-1) and
p2k+1 = p2k – 2rx2yk+1+rx2 Otherwise the next point along the ellipse is (xk+1,yk-1) and
p2k+1 = p2k + 2ry2xk+1 – 2rxx2yk+1 + rx2 Using the same incremental calculations for x any y as in region 1.

6. Determine symmetry points in the other three quadrants.

7. Move each calculate pixel position (x,y) onto the elliptical path centered on (xc,yc) and plot the coordinate values

x=x+xc, y=y+yc

1. Repeat the steps for region1 unit 2ry2x>=2rx2y

Example : Mid point ellipse drawing

Input ellipse parameters $r_x=8$ and $r_y=6$ the mid point ellipse algorithm by determining raster position along the ellipse path is the first quadrant. Initial values and increments for the decision parameter calculations are

$2r_y^2\ x=0$ (with increment $2r_y^2=72$)
$2r_x^2\ y=2r_x^2\ r_y$ (with increment $-2r_x^2= -128$)

For region 1 the initial point for the ellipse centered on the origin is (x_0,y_0) = (0,6) and the initial decision parameter value is

$p1_0=r_y^2-r_x^2r_y^2+1/4r_x^2=-332$

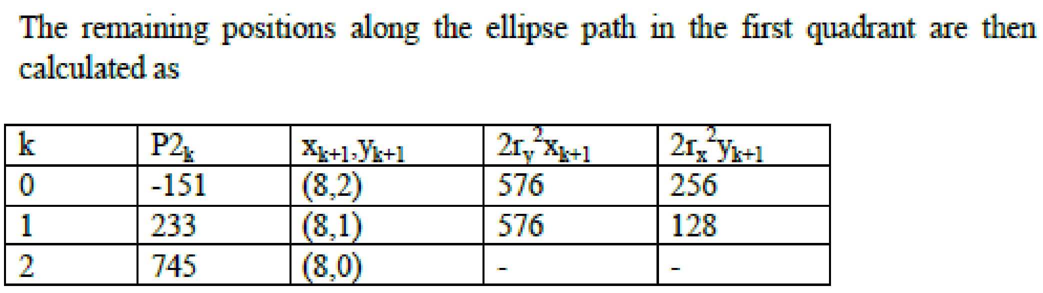
Successive midpoint decision parameter values and the pixel positions along the ellipse are listed in the following table.

k	$p1_k$	x_{k+1},y_{k+1}	$2r_y^2x_{k+1}$	$2r_x^2y_{k+1}$
0	-332	(1,6)	72	768
1	-224	(2,6)	144	768
2	-44	(3,6)	216	768
3	208	(4,5)	288	640
4	-108	(5,5)	360	640
5	288	(6,4)	432	512
6	244	(7,3)	504	384

Move out of region 1, $2ry2x > 2rx^2y$.

For a region 2 the initial point is (x_0,y_0)=(7,3) and the initial decision parameter is

$p2_0 = f_{ellipse}(7+1/2,2) = -151$



The remaining positions along the ellipse path in the first quadrant are then calculated as

k	$P2_k$	x_{k+1}, y_{k+1}	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
0	-151	(8,2)	576	256
1	233	(8,1)	576	128
2	745	(8,0)	-	-

5. Explain Line drawing algorithm. (AU NOV/DEC 2012)

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.

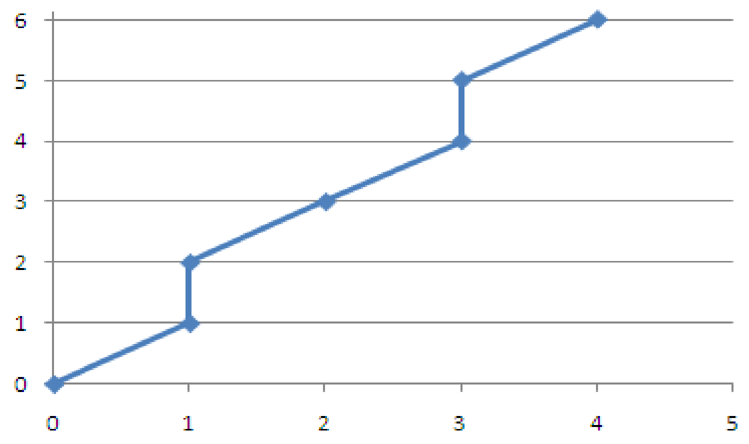
Example: Consider the line from (0,0) to (4,6)

1. xa=0, ya =0 and xb=4 yb=6
2. dx=xb-xa = 4-0 = 4 and dy=yb-ya=6-0= 6

3. x=0 and y=0
4 > 6 (false) so, steps=6
5. Calculate xIncrement = dx/steps = 4 / 6 = 0.66 and yIncrement = dy/steps =6/6=1
6. Setpixel(x,y) = Setpixel(0,0) (Starting Pixel Position)
7. Iterate the calculation for xIncrement and yIncrement for steps(6) number of times
8. Tabulation of the each iteration

k	x	Y	Plotting points (Rounded to Integer)
0	0+0.66=0.66	0+1=1	(1,1)
1	0.66+0.66=1.32	1+1=2	(1,2)
2	1.32+0.66=1.98	2+1=3	(2,3)
3	1.98+0.66=2.64	3+1=4	(3,4)
4	2.64+0.66=3.3	4+1=5	(3,5)

RESULT:



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

6. Write short notes on Video display devices.

<u>**2.1 VIDEO DISPLAY DEVICES**</u>

Typically, 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 exist and solid-state* monitors may eventually predominate.

REFRESH CATHODE-RAY TUBES

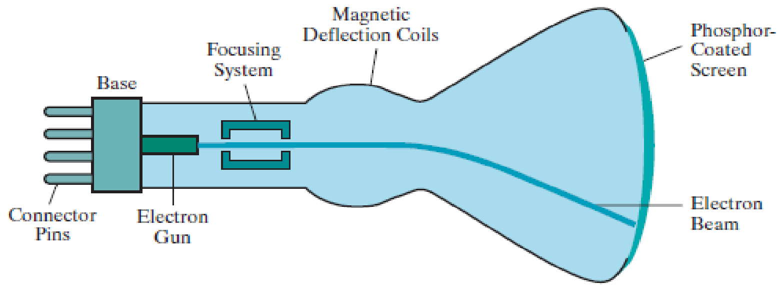


FIGURE 2-2 Basic design of a magnetic-deflection CRT.

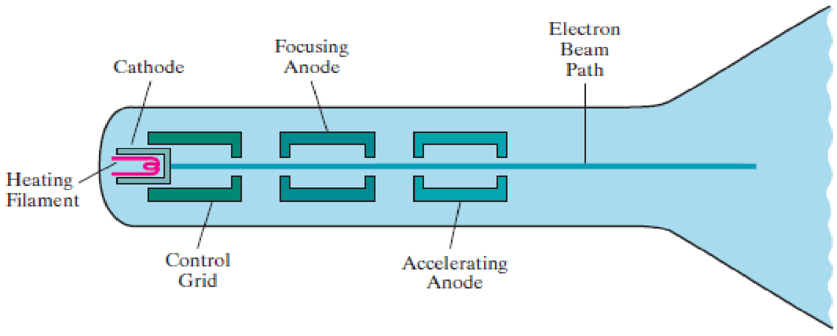


FIGURE 2-3 Operation of an electron gun with an accelerating anode.

1. Figure 2-2 illustrates the basic operation of a CRT. 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.
2. 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,
3. Some method is needed for maintaining the screen picture. One way to do this is to store the picture information as a charge distribution within the CRT.
4. This charge distribution can then be used to keep the phosphors activated. However, the most common method now employed for maintaining phosphor glow is to redraw the picture repeatedly by quickly directing the electron beam back over the same screen points.
5. This type of display is called a **refreshCRT,** and the frequency at which a picture is redrawn on the screen is referred to as the **refresh rate.** The primary components of an electron gun in a CRT are the heated metal cathode and a control grid (Fig. 2-3).
6. Heat is supplied to the cathode by directing a current through a coil of wire, called the filament, inside the cylindrical cathode structure. This causes electrons to be "boiled off" the hot cathode surface.
7. In the vacuum inside the CRT envelope, the free, negatively charged electrons are then accelerated toward the phosphor coating by a high positive voltage. The accelerating voltage can be generated with a positively charged metal coating on the inside of the CRT envelope near the phosphor screen, or an accelerating anode, as in Fig. 2-3, can be used to provide the positive voltage.
8. Sometimes the electron gun is designed so that the accelerating anode and focusing system are within the same unit.
9. Intensity of the electron beam is controlled by the voltage at the control grid, which is a metal cylinder that fits over the cathode. 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.
10. 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, the brightness of a display point is controlled by varying the voltage on the control grid.
11. The focusing system in a CRT forces the electron beam to converge to a small cross section as it strikes the phosphor. Otherwise, the electrons would repel eachother, and the beam would spread out as it approaches the screen. Focusing is accomplished with either electric or magnetic fields.
12. With electrostatic focusing, the electron beam is passed through a positively charged metal cylinder so that electrons along the centerline of the cylinder are in an equilibrium position.

13. This arrangement forms an electrostatic lens, as shown in Fig. 2-3, and the electron beam is focused at the center of the screen in the same way that an optical lens focuses a beam of light at a particular focal distance. Similar lens focusing effects can be accomplished with a magnetic field set up by a coil mounted around the outside of the CRT envelope, and magnetic lens focusing usually produces thesmallest spot size on the screen.
14. Additional focusing hardware is used in high-precision systems to keep the beam in focus at all screen positions. The distance that the electron beam must travel to different points on the screen varies because the radius of curvature for most CRTs is greater than the distance from the focusing system to the screen center.
15. Therefore, the electron beam will be focused properly only at the center of the screen. As the beam moves to the outer edges of the screen, displayed images become blurred. To compensate for this, the system can adjust the focusing according to the screen position of the beam.
16. As with focusing, deflection of the electron beam can be controlled with either electric or magnetic fields. Cathode-ray tubes are now commonly constructed with magnetic-deflection coils mounted on the outside of the CRT envelope, as illustrated in Fig. 2-2.
17. Two pairs of coils are used for this purpose. One pair is mounted on the top and bottom of the CRT 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 to both the direction of the magnetic field and the direction of travel of the electron beam.
18. Horizontal deflection is accomplished with one pair of coils, and vertical deflection with the other pair. The proper deflection amounts are attained by adjusting the currentthrough the coils. When electrostatic deflection is used, two pairs of parallel plates are mounted inside the CRT envelope.

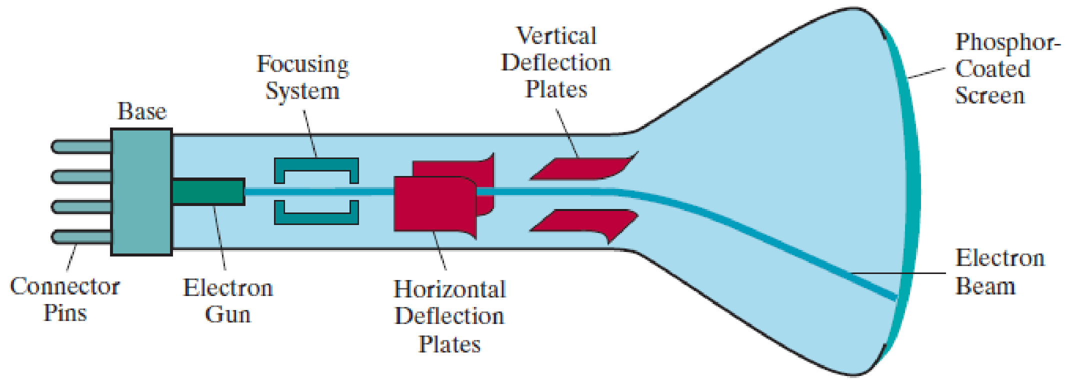


Fig 2.4 Electrostatic deflection of the electron beam in a CRT.

19. One pair of plates is mounted horizontally to control vertical deflection, and the other pair is mounted vertically to control horizontal deflection (Fig. 2-4). Spots of light are produced on the screen by the transfer of the CRT beam energy to the phosphor. When the electrons in the beam collide with the phosphor coating, they are stopped and their kinetic energy is absorbed by the phosphor. Part of the beam energy is converted by friction into heat energy, and the remainder causes electrons in the phosphor atoms to move up to higher quantum-energy levels. After a short time, the “excited” phosphor electrons begin dropping back to their stable ground state, giving up their extra energy as small quantum’s of light energy called photons.
20. Different kinds of phosphors are available for use in CRTs. Besides color, a major difference between phosphors is their **persistence:** how long they continue to emit light (that is, how long before all excited electrons have returned to the ground state) after the CRT beam is removed. Persistence is defined as the time that it takes the emitted light from the screen to decay to one-tenth of its original intensity.
21. Lower-persistence phosphors require higher refresh rates to maintain a picture on the screen without flicker. A phosphor with low persistence can be useful for animation, while high-persistence phosphors are better suited for displaying highly complex, static pictures. Although some phosphors have persistence values greater than 1 second, general-purpose graphics monitors are usually constructed with persistence in the range from 10 to 60 microseconds.
22. Figure 2-5 shows the intensity distribution of a spot on the screen. The intensity is greatest at the center of the spot, and it decreases with a Gaussian distribution out to the edges of the spot. This distribution corresponds to the cross-sectional electron density distribution of the CRT beam. The maximum number of points that can be displayed without overlap on aCRT is referred to as the **resolution**

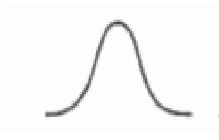


Fig 2.5 Intensity distribution of an illuminated Phosphor spot on a CRT screen

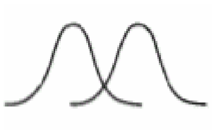


Fig 2.6 Two Illuminated phosphor spots are distinguishable when their separation is greater than the diameter at which a spot intensity has fallen to 60 percent of maximum.

7. Explain the basic concept of midpoint ellipse drawing algorithm. Derive the decision parameter for the algorithm and write down the algorithm steps

BRESENHAM'S ELLIPSE GENERATING ALGORITHM

Midpoint Ellipse Algorithm

6. Input rx,ry and ellipse center (xc,yc) and obtain the first point on an ellipse centered on the origin as (x0,y0) = (0,ry)
7. Calculate the initial value of the decision parameter in region 1 as

   P10=ry2-rx2ry +(1/4)rx2

   At each xk position in region1 starting at k=0 perform the following test.
8. If P1k<0, the next point along the ellipse centered on (0,0) is (xk+1, yk) and

   p1k+1 = p1k +2 ry2xk +1 + ry2
9. Otherwise the next point along the ellipse is (xk+1, yk-1) and

   p1k+1 = p1k +2 ry2xk +1 - 2rx2 yk+1 + ry2

   with 2 ry2xk +1 = 2 ry2xk + 2ry2 2 rx2yk +1 = 2 rx2yk + 2rx2

   And continue until 2ry2 x>=2rx2 y
10. Calculate the initial value of the decision parameter in region 2 using the last point (x0,y0) is the last position calculated in region 1.

    p20 = ry2(x0+1/2)2+rx2(yo-1)2 – rx2ry2

6. At each position yk in region 2, starting at k=0 perform the following test, If p2k>0 the next point along the ellipse centered on (0,0) is (xk,yk-1) and

p2k+1 = p2k – 2rx2yk+1+rx2 Otherwise the next point along the ellipse is (xk+1,yk-1) and
p2k+1 = p2k + 2ry2xk+1 – 2rxx2yk+1 + rx2 Using the same incremental calculations for x any y as in region 1.

6. Determine symmetry points in the other three quadrants.

7. Move each calculate pixel position (x,y) onto the elliptical path centered on (xc,yc) and plot the coordinate values

x=x+xc, y=y+yc

2. Repeat the steps for region1 unit 2ry2x>=2rx2y

Example : Mid point ellipse drawing

Input ellipse parameters r_x=8 and r_y=6 the mid point ellipse algorithm by determining raster position along the ellipse path is the first quadrant. Initial values and increments for the decision parameter calculations are

$$2r_y^2\, x=0 \text{ (with increment } 2r_y^2=72)$$
$$2r_x^2\, y=2r_x^2\, r_y \text{ (with increment } -2r_x^2= -128)$$

For region 1 the initial point for the ellipse centered on the origin is (x_0,y_0) = (0,6) and the initial decision parameter value is

$p1_0=r_y^2-r_x^2r_y^2+1/4r_x^2=-332$

Successive midpoint decision parameter values and the pixel positions along the ellipse are listed in the following table.

k	$p1_k$	x_{k+1},y_{k+1}	$2r_y^2x_{k+1}$	$2r_x^2y_{k+1}$
0	-332	(1,6)	72	768
1	-224	(2,6)	144	768
2	-44	(3,6)	216	768
3	208	(4,5)	288	640
4	-108	(5,5)	360	640
5	288	(6,4)	432	512
6	244	(7,3)	504	384

Move out of region 1, 2ry2x >2rx^{2}y .

For a region 2 the initial point is (x_0,y_0)=(7,3) and the initial decision parameter is

$$p2_0 = f_{ellipse}(7+1/2,2) = -151$$

The remaining positions along the ellipse path in the first quadrant are then calculated as

k	$P2_k$	x_{k+1},y_{k+1}	$2r_y^2x_{k+1}$	$2r_x^2y_{k+1}$
0	-151	(8,2)	576	256
1	233	(8,1)	576	128
2	745	(8,0)	-	-

8. Explain about Random scan systems.

RANDOM-SCAN DISPLAYS

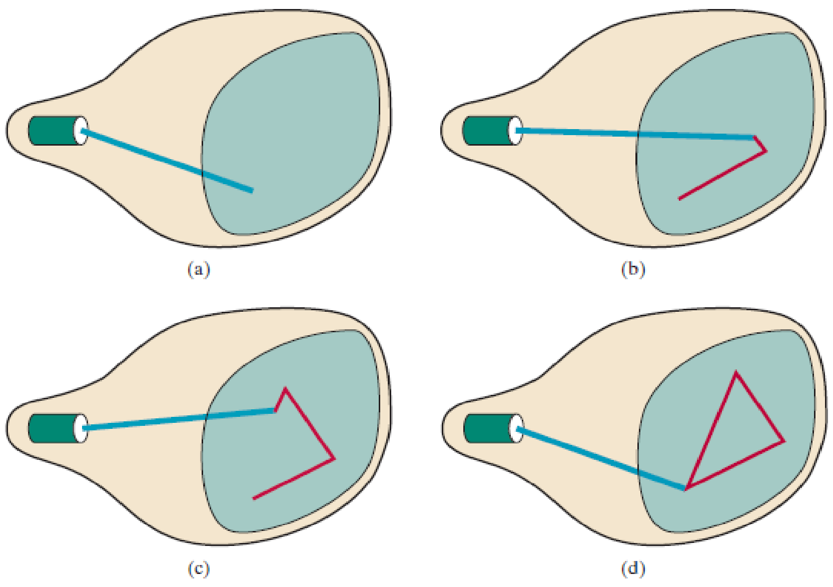


FIGURE 2-9 A random-scan system draws the component lines of an object in any specified order.

1. When operated as a **random-scan display** unit, a CRT has the electron beam directed only to those parts of the screen where a picture is to be displayed.
2. Pictures are generated as line drawings, with the electron beam tracing out the component lines one after the other. For this reason, random-scan monitors are also referred to as **vector displays** (or **stroke-writing displays** or **calligraphic displays**).
3. The component lines of a picture can be drawn and refreshed by a random-scan system in any specified order (Fig. 2-9).A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.
4. Refresh rate on a random-scan system depends on the number of lines to be displayed on that system. Picture definition is now stored as a set of line-drawing commands in an area of memory referred to as the **display list, refresh display file, vector file,** or **display program.**
5. To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn. After all line-drawing commands have been processed, the system cycles back to the first line command in the list.
6. Random-scan displays are designed to draw all the component lines of a picture 30 to 60 times each second, with up to 100,000 "short" lines in the display list. When a small set of lines is to be displayed, each refresh cycle is delayed to avoid very high refresh rates, which could burn out the phosphor.
7. Random-scan systems were designed for line-drawing applications, such as architectural and engineering layouts, and they cannot display realistic shaded scenes. Since picture definition is stored as a set of line-drawing instructions rather than as a set of intensity values for all screen points, vector displays generally have higher resolutions than raster systems.
8. Also, vector displays produce smooth line drawings because the CRT beam directly follows the line path. A raster system, by contrast, produces jagged lines that are plotted as discrete point sets. However, the greater flexibility and improved line-drawing capabilities of raster systems have resulted in the abandonment of vector technology.
9. **Explain about Raster scan systems.**

RASTER-SCAN DISPLAYS

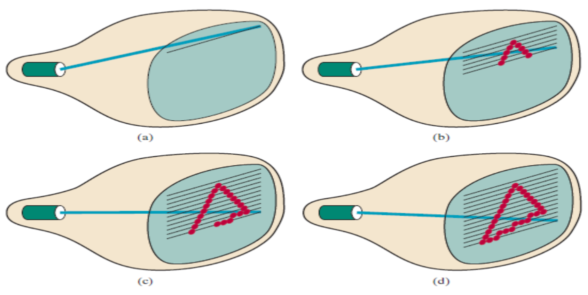


FIGURE 2–7 A raster-scan system displays an object as a set of discrete points across each scan line.

1. The most common type of graphics monitor employing a CRT is the **raster-scan display,** based on television technology. Ina raster-scan system, the electron beam is swept across the screen, one row at a time, from top to bottom.
2. Each row is referred to as a **scan line.** As the electron beam moves across a scan line, the beam intensity is turned on and off (or set to some intermediate value) to create a pattern of illuminated spots. Picture definition is stored in a memory area called the **refresh buffer** or **frame buffer,** where the term **frame** refers to the total screen area. This memory area holds the set of color values for the screen points.
3. These stored color values are then retrieved from the refresh buffer and used to control the intensity of the electron beam as it moves from spot to spot across the screen. In this way, the picture is "painted" on the screen one scan line at a time, as demonstrated in Fig. 2-7.
4. Each screen spot that can be illuminated by the electron beam is referred to as a **pixel** or **pel**(shortened forms of **picture element**). Since the refresh buffer is used to store the set of screen color values, it is also sometimes called a **color buffer.**
5. Also, other kinds of pixel information, besides color, are stored in buffer locations, so all the different buffer areas are sometimes referred to collectively as the "frame buffer". The capability of a raster-scan system to store color information for each screen point makes it well suited for the realistic display of scenes containing subtle shading and color patterns.
6. Home television sets and printers are examples of other systems using raster-scan methods. Raster systems are commonly characterized by their resolution, which is the number of pixel positions that can be plotted.
7. Another property of video monitors is **aspect ratio,** which is now often defined as the number of pixel columns divided by the number of scan lines that can be displayed by the system. (Sometimes the term aspect ratio is used to refer to the number of scan lines divided by the number of pixel columns.) Aspect ratio can also be described as the number of horizontal points to vertical points (or vice versa) necessary to produce equal-length lines in both directions on the screen.
8. The number of bits per pixel in a frame buffer is sometimes referred to as either the **depth** of the buffer area or the number of **bit planes.** Also, a frame buffer with one bit per pixel is commonly called a **bitmap,** and a frame buffer with multiple bits per pixel is a **pixmap.**

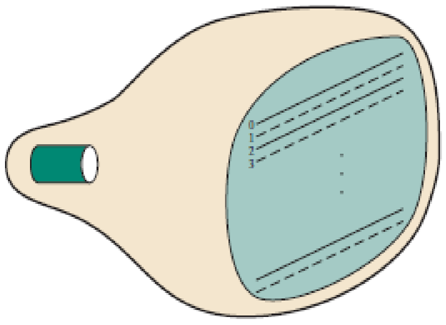


FIGURE 2-8 Interlacing scan lines on a raster-scan display. First, all points on the even-numbered (solid) scan lines are displayed; then all points along the odd-numbered (dashed) lines are displayed.

9. On some raster-scan systems and TV sets, each frame is displayed in two passes using an *interlaced* refresh procedure. In the first pass, the beam sweeps across every other scan line from top to bottom. After the vertical retrace, the beam then sweeps out the remaining scan lines (Fig. 2-8).
10. 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. This technique is primarily used with slower refresh rates. On an older, 30 frame per- second, non-interlaced display, for instance, some flicker is noticeable. But with interlacing, each of the two passes can be accomplished in 1/60 of a second, which brings the refresh rate nearer to 60 frames per second. This is an effective technique for avoiding flicker provided that adjacent scan lines contain similar display information.

10. Write short notes on pixel addressing and object geometry.

Unit II
TWO DIMENSIONAL GRAPHICS
PART-A

1.What are homogeneous co-ordinates?(AU MAY/JUNE 2012 IT)

To express any 2D transformation as a matrix multiplication, each Cartesian co-ordinate position (x, y) is represented with the homogeneous coordinate triple (xh, yh, h) where $x=\frac{xh}{h}$ and $y=\frac{yh}{h}$. Thus the general homogeneous coordinate representation can also be written as (h.x, h.y, h). The homogeneous parameter h can be any nonzero value. A convenient choice is to set h=1. Each 2D position is then represented by the homogeneous coordinates (x, y, 1).

2.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 circularpath in the xy plane.

$$P1=R.P$$

$$R=\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \quad \theta\text{- rotation angle}$$

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

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

3.How can we express a two dimensional geometric transformation?

We can express two-dimensional geometric transformations as 3 by 3 matrixoperators, so that sequences of transformations can be concatenated into a single composite matrix. This is an efficient formulation, since it allows us to reducecomputations by applying the composite matrix to the initial coordinate positionsof an object to obtain the final transformed positions

4.What is uniform and differential scaling?

Uniform scaling: Sx and Sy are assigned the same value.

Differential scaling: unequal values for Sx and Sy.

5.Define reflection.

A reflection is a transformation that produces a mirror image of an object.

By line y =0(x-axis)

$$\text{Transformation matrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

By the x axis

$$\text{transformation matrix} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

6.Write down the shear transformation matrix. (AU NOV/DEC 2012)

A transformation that distorts the shape of an object such that the transformed shape appears as if theobject is composed of internal layers that had been caused to slide over each other is called shear.x-direction shear relative to x axis

$$\begin{bmatrix} 1 & shx & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

x-direction shear relative to other reference lines

$$\begin{bmatrix} 1 & shx & -shx.yref \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

y-direction shear relative to $x=x_{ref}$

$$\begin{bmatrix} 1 & 0 & 0 \\ shy & 1 & -shy.xref \\ 0 & 0 & 1 \end{bmatrix}$$

7.What is the rule of clipping? (AU MAY/JUNE 2012)

For the viewing transformation, we are needed to display only those picture parts that are within thewindow area. Everything outside the window is discarded. Clipping algorithms are applied in world coordinates,so that only the contents of the window interior are mapped to device co-ordinates.

8.Define clipping.(AU NOV/DEC 2012)

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

9.Define Translation?

A translation is applied to an object by repositioning it along a straight-line path from one coordinate location to another. We translate a two-dimensional point by adding translation distances, *f,* and t,, to the original coordinate position (x, y) to move the point to a new position

(x ' , y')

x' = *x* + *t*,, y' = y + *t,*

The translation distance pair *(t,, t,)* is called a translation vector or shift vector.

10.Define 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) of each vertex by scaling factors s, and s, to produce the transformed coordinates **(x',** y'):

$$x' = x \cdot s_x, \qquad y' = y \cdot s_y$$

Scaling factor s, scales objects in the **x** direction, while sy scales in their direction.

11. Define reflection?

A reflection is a transformation that produces a mirror image of an object. The mirror image for a two-dimensional reflection is generated relative to an **axis** of reflection by rotating the object 180" about the reflection axis. We can choose an axis of reflection in the *xy*plane or perpendicular to the *xy*plane. When the reflection axis is a line in the *xy*plane, the rotation path about this axis is in a plane perpendicular to the *xy*plane. For reflection axes that are perpendicular to the *xy*plane, the rotation path is in the *xy*plane.

12. What is shear?

A transformation that distorts the shape of an object such that the transformed shape appears as if the object were composed of internal layers that had been caused to slide over each other is called a shear. Two common shearing transformations are those that shift coordinate w values and those that shift y values.

13. What is affine transformation?

A coordinate transformation of the form

$$x' = a_{xx}x + a_{xy}y + b_x, \qquad y' = a_{yx}x + a_{yy}y + b_y$$

is called a two-dimensional affine transformation. Each of the transformed coordinates *x'* and y ' is a linear function of the original coordinates *x* and y, and parameters a,, and *bk*are constants determined by the transformation type. Affine transformations have the general properties that parallel lines are transformed into parallel lines and finite points map to finite points.Translation, rotation, scaling, reflection, and shear are examples of two-dimensional affine transformations.

14. What is viewing transformation?

The window defines *what* is to be viewed; the viewport defines *where* it is to be displayed.Often, windows and viewports are rectangles in standard position, with the rectangle edges parallel to the coordinate axes. Other window or viewport geometries,such as general polygon shapes and circles, are used in some applications,but these shapes take longer to process. In general, the mapping of a part of a world-coordinate scene to device coordinates is referred to as a **viewing transformation**

15. What are the various line clipping algorithm?

Cohen-Sutherland line clipping

Liang-Barsky line clipping

Nicholl-Lee-Nicholl line clipping

16. Differentiate window and viewport(AU NOV/DEC 2011)

Window	Viewport
A window is a world coordinate area selected for display	A viewport is an area on a display device to which the window is mapped
The window defines what is to be viewed	The viewport defines where it is to be displayed

17. What are the various polygon clipping algorithms?
Sutherland-Hodgenialpolvgon Clipping
Welter-Atherton Polygon Clipping

18. List the different types of text clipping methods available?
There are several techniques that can be used to provide text clipping in a graphics package. The clipping technique used will depend on the methods used to generate characters and the requirements of a particular application.The simplest method for processing character strings relative to a window boundary is to use the **all-or-none string-clipping** strategy. An alternative to rejecting an entire character string that overlaps a window boundary is to use the all-or-none **character-clipping** strategy.**A** final method for handling text clipping is to clip the components of individual characters. We now treat characters in much the same way that we treated lines. If an individual character overlaps a clip window boundary, we clip off the parts of the character that are outside the window (Fig. 6-30). Outline character fonts formed with line segments can be processed in this way using a line clipping algorithm.

19. How will you clip a point?
Assuming that the clip window is a rectangle in standard position, we save a point P = *(x,* y) for display if the following inequalities are satisfied:

$$xw_{min} \le x \le xw_{max}$$

$$yw_{min} \le y \le yw_{max}$$

Where the *edges of* the clip window (numi,, mum,, *yw,,, yiu,,,)* can be either the world-coordinate window boundaries or viewport boundaries. If any one of these four inequalities is not satisfied, the point is clipped (not saved for display).Although point clipping is applied less often than line or polygon clipping,some .applications may require a point clipping procedure. For example, point clipping can be applied to scenes involving explosions or sea foam that are modeled with particles (points) distributed in some region of the scene.

20. Give an example for text clipping?
We now treat characters in much the same way that we treated lines. If an individual character overlaps a clip window boundary, we clip off the parts of the character that are outside the window. Outline character fonts formed with line segments can be processed in this way using a line clipping algorithm.

21. Define Exterior clipping.
We have considered only procedures for clipping a picture to the interior of a screen by eliminating everything outside the clipping region. What is saved by these procedures is *inside* the region. In some cases, we want to do the reverse,that is, we want to clip a picture to the exterior of a specified region. The picture parts to be saved are those that are *outside* the region. This is referred to as exterior clipping.

22. Define curve clipping.
Curve-clipping procedures will involve non- linear equations, however, and this requires more processing than for objects with linear boundaries.The bounding rectangle for a circle or other curved object can beused first to test for overlap with a rectangular clip window. If the bounding rectangle for the object is completely inside the window, we save the object. If the rectangle is determined to be completely outside the window, we discard the object. In either case, there is no further computation necessary. But if the bounding rectangle test fails, we can look for other computation-saving approaches. For a circle, we can use the coordinate extents of individual quadrants and then octants for preliminary testing before calculating curve-window intersections.

23. Define window to viewport coordinate transformation.
Once object descriptions have been transferred to the viewing reference frame,we choose the window extents in viewing coordinates and select the viewport limits in normalized coordinates Object descriptions are then transferredto normalized device coordinates. We do this using a transformation that maintains the same relative placement of objects in normalized space as they had in viewing coordinates. If a coordinate position is at the center of the viewing window, for instance, it will be displayed at the center of the viewport.

24.Define clip window?
Generally, 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 algo**rithm,or simply clipping. The region against which an object is to be clipped is called a clip **window.**

25.What are the various applications of clipping?

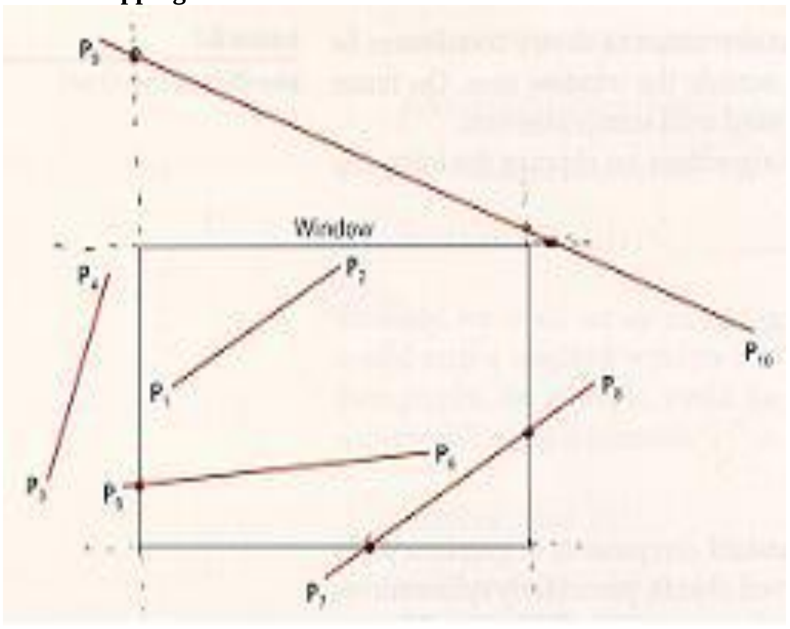
Applications of clipping include extracting part of a defined scene for viewing; identifying visible surfaces in three-dimensiona1 views; antialiasing line ***seg***mentsor object boundaries; creating objects using solid-modeling procedures;displaying a multi-window environment; and drawing and painting operations that allow parts of a picture to be selected for copying, moving, erasing, or duplicating.Depending on the application, the clip window can be a general polygon or it can even have curved boundaries.

Part B

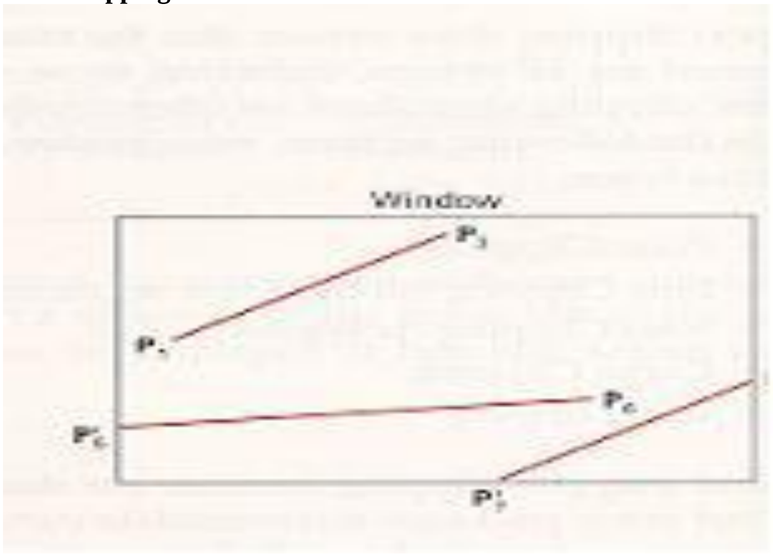
1. **Explain Line clipping algorithm.**

<u>Line Clipping:</u>

Before Clipping



After Clipping



1. Parametric representation of Line segment with endpoints (x1, y1) and (x2, y2)

$x = x_1 + u(x_2-x_1)$

$y = y_1 + u(y_2-y_1)$; 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

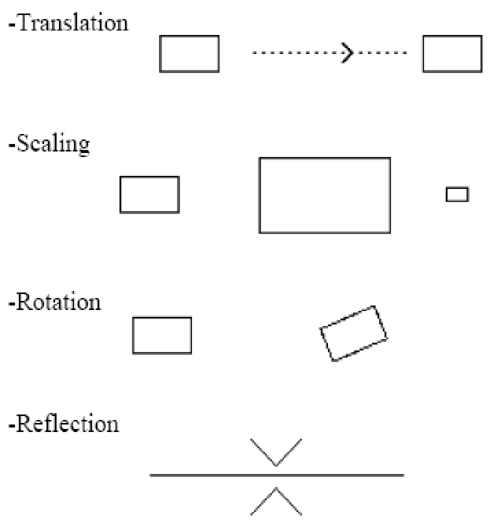
2. **Explain the rotational transformations.**

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
4. Reflection
5. shearing

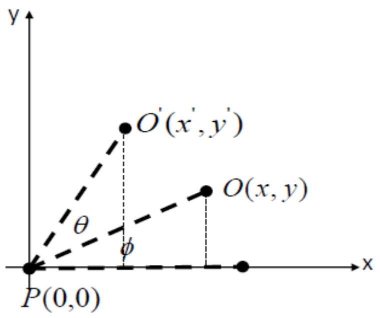


Two-Dimensional Rotation

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

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



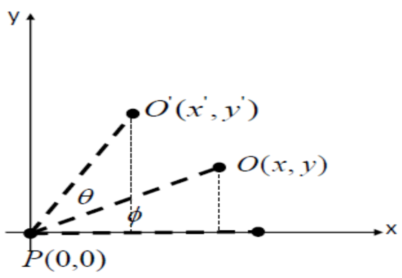
Polar coordinate system

$$x = r\cos\phi$$
$$y = r\sin\phi$$

$$\Downarrow$$

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

The two-dimensional rotation



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

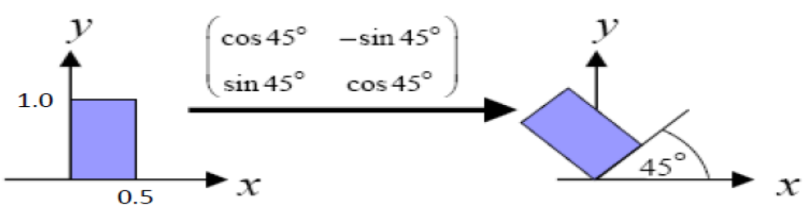
$$O' = R \bullet O$$

โดยที่

$$O = \begin{bmatrix} x \\ y \end{bmatrix} \qquad O' = \begin{bmatrix} x' \\ y' \end{bmatrix}$$

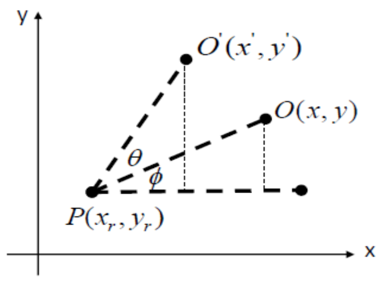
และ $R = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \longleftarrow$ Rotation matrix

Ex. 1


y
1.0
0.5
x
$\begin{pmatrix} \cos 45^\circ & -\sin 45^\circ \\ \sin 45^\circ & \cos 45^\circ \end{pmatrix}$
y
45°
x

Rotation of a point about an arbitrary pivot position

$$x' = (x - x_r)\cos\theta - (y - y_r)\sin\theta + x_r$$
$$y' = (x - x_r)\sin\theta + (y - y_r)\cos\theta + y_r$$



$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x - x_r \\ y - y_r \end{bmatrix} + \begin{bmatrix} x_r \\ y_r \end{bmatrix}$$

$$O' = R \bullet O^* + P$$

โดยที่

$$O^* = \begin{bmatrix} x - x' \\ y - y' \end{bmatrix}$$

3. **Explain Curve clipping algorithm**

Areas with curved boundaries can be clipped with methods similar to those discussed in the previous .sections. Curve-clipping procedures will involve nonlinear equations, however, and this requires more processing than for objects with linear boundaries. The bounding rectangle for a circle or other curved object can **be** used first to test for overlap with a rectangular clip window. If the bounding rectangle for
the object is completely inside the window, we save the object. If the rectangle is determined to be completely outs~deth e window, we discard the object. In either case, there is no further computation necessary. But if the bounding rectangle test fails, we can lwk for other computation-saving approaches. For a circle, we can use the coordinate extents of individual quadrants and then octants for preliminary
testing before calculating curve-window intersections. For an ellipse, we can test the coordinate extents of individual quadrants. Figure 6-27 illustrates circle clipping against a rectangular window. Similar procedures can **be** applied when clipping a curved object against a general polygon clip region. On the first pass, we can clip the bounding rectangle of the object against the bounding rectangle of the clip region. If the two regions overlap, we will need to solve the simultaneous line-curve equations to obtain the clipping intersection points

4. **Write a detailed note on the basic two dimensional transformations**

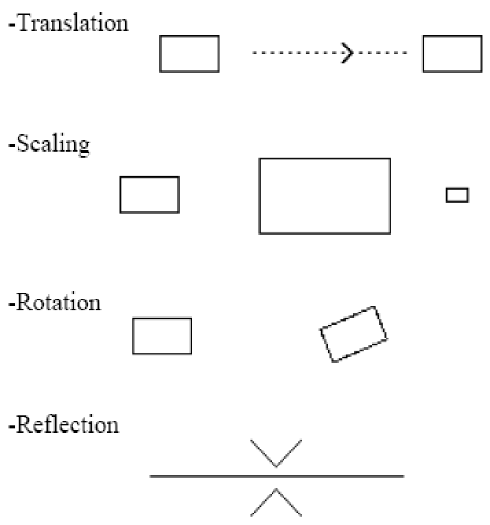
BASIC TWO-DIMENSIONAL GEOMETRIC TRANSFORMATIONS

1. Operations that are applied to the geometric description of an object to change its position, orientation, or size are called ***geometric transformations***.
2. 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

6. Translation
7. Rotation
8. Scaling
9. Reflection

10. shearing



Two-Dimensional Translation

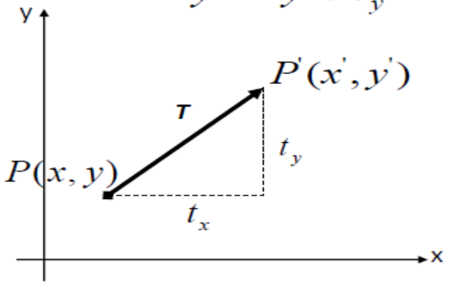
1. We perform a translation on a single coordinate point by adding offsets to its coordinates so as to generate a new coordinate position.
2. To translate a two-dimensional position, we add translation distances, tx and ty to the original coordinates (x,y) to obtain the new coordinate position (x',y'),

$$\mathbf{X' = X + t_x}$$

$$\mathbf{Y' = Y + t_y}$$

The two-dimensional translation equations in the matrix form

$$x' = x + t_x$$
$$y' = y + t_y$$



$$P = \begin{bmatrix} x \\ y \end{bmatrix} \qquad P' = \begin{bmatrix} x' \\ y' \end{bmatrix}$$

$$T = \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

$$P' = P + T$$

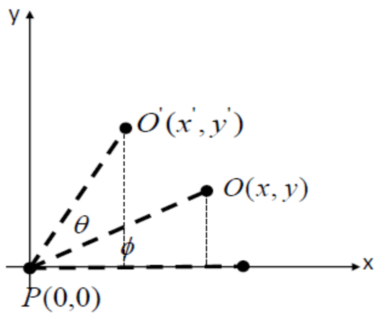
Two-Dimensional Rotation

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

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



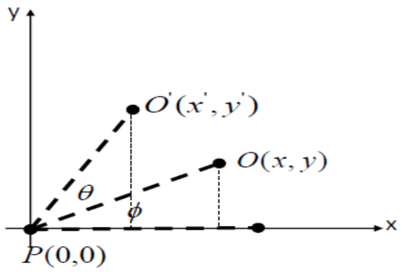
Polar coordinate system

$$x = r\cos\phi$$
$$y = r\sin\phi$$

$$\downarrow$$

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

The two-dimensional rotation



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

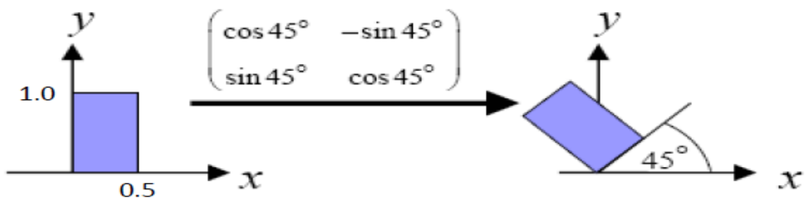
$$O' = R \bullet O$$

โดยที่

$$O = \begin{bmatrix} x \\ y \end{bmatrix} \qquad O' = \begin{bmatrix} x' \\ y' \end{bmatrix}$$

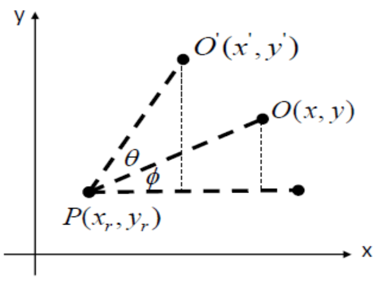
และ $R = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \longleftarrow$ Rotation matrix

Ex. 1


y
1.0
0.5
x
$\begin{pmatrix} \cos 45^\circ & -\sin 45^\circ \\ \sin 45^\circ & \cos 45^\circ \end{pmatrix}$
y
45°
x

Rotation of a point about an arbitrary pivot position

$$x' = (x - x_r)\cos\theta - (y - y_r)\sin\theta + x_r$$
$$y' = (x - x_r)\sin\theta + (y - y_r)\cos\theta + y_r$$



$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x - x_r \\ y - y_r \end{bmatrix} + \begin{bmatrix} x_r \\ y_r \end{bmatrix}$$

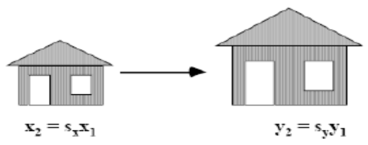
$$O' = R \bullet O^* + P$$

โดยที่

$$O^* = \begin{bmatrix} x - x' \\ y - y' \end{bmatrix}$$

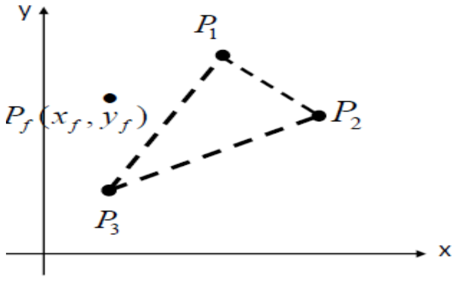
Two-Dimensional Scaling

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



$$x = x \cdot s_x$$
$$y' = y \cdot s_y$$
$$\downarrow$$
$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$
$$P' = S \bullet P$$

Scaling relative to a chosen fixed point



$$x' = x \cdot s_x + x_f(1 - s_x)$$
$$y' = y \cdot s_y + y_f(1 - s_y)$$
$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 1 - s_x & 0 \\ 0 & 1\text{-}s_y \end{bmatrix} \begin{bmatrix} x_f \\ y_f \end{bmatrix}$$
$$P' = S \bullet P + S^* \bullet P_f$$

5. **Explain the two dimensional Translation and scaling with example**

Two-Dimensional Translation

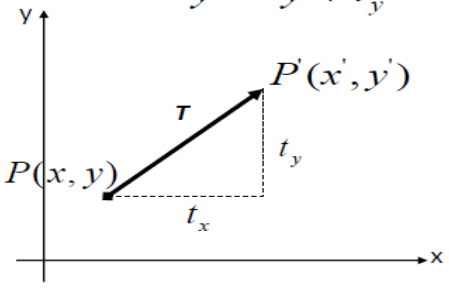
1. We perform a translation on a single coordinate point by adding offsets to its coordinates so as to generate a new coordinate position.
2. To translate a two-dimensional position, we add translation distances, tx and ty to the original coordinates (x,y) to obtain the new coordinate position (x',y'),

$X' = X + t_x$

$Y' = Y + t_y$

The two-dimensional translation equations in the matrix form

$$x' = x + t_x$$
$$y' = y + t_y$$

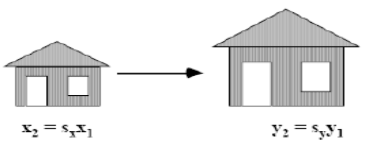


$$P = \begin{bmatrix} x \\ y \end{bmatrix} \qquad P' = \begin{bmatrix} x' \\ y' \end{bmatrix}$$
$$T = \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$
$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$
$$P' = P + T$$

Two-Dimensional Scaling

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

5. 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').
6. 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



$$x = x \cdot s_x$$

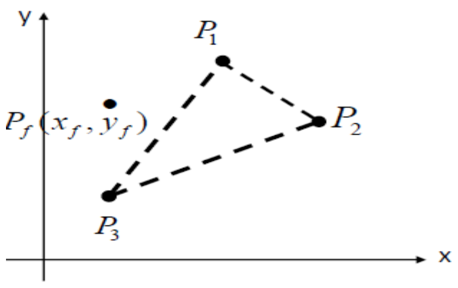
$$y' = y \cdot s_y$$

$$\Downarrow$$

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

$$P' = S \bullet P$$

Scaling relative to a chosen fixed point



$$x' = x \cdot s_x + x_f(1 - s_x)$$

$$y' = y \cdot s_y + y_f(1 - s_y)$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 1 - s_x & 0 \\ 0 & 1\text{-}s_y \end{bmatrix} \begin{bmatrix} x_f \\ y_f \end{bmatrix}$$

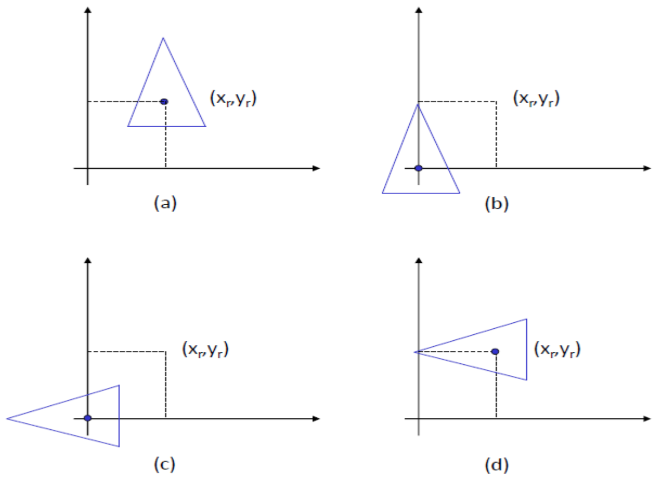
$$P' = S \bullet P + S^* \bullet P_f$$

6. **Obtain a transformation matrix for rotating an object about a specified pivot point**

<u>General Two-dimensional Pivot-Point Rotation</u>

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.



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

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

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

7. **Explain Cohen-Sutherland Line clipping algorithm. (AU NOV 2011 & MAY 2012)**

<u>Cohen-Sutherland Line Clipping :</u>

1. Region Code Creation

–Region Code

•Bit 1: left

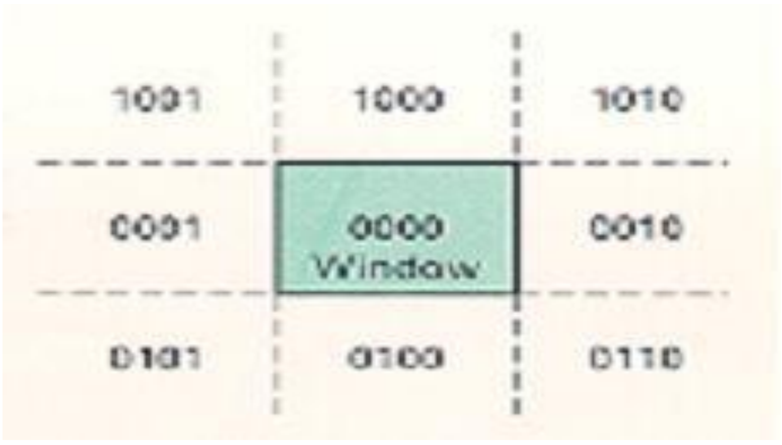
•Bit 2: right

•Bit 3: below

•Bit 4: above

–Calculate differences between endpoint coordinates and clipping boundaries

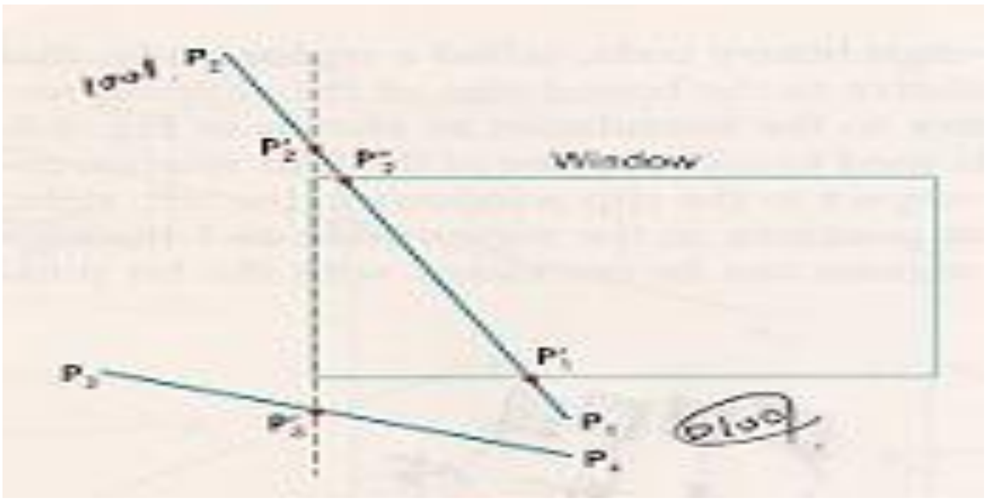
–Use the resultant sign bit of each difference calculation to set the corresponding value in the region code



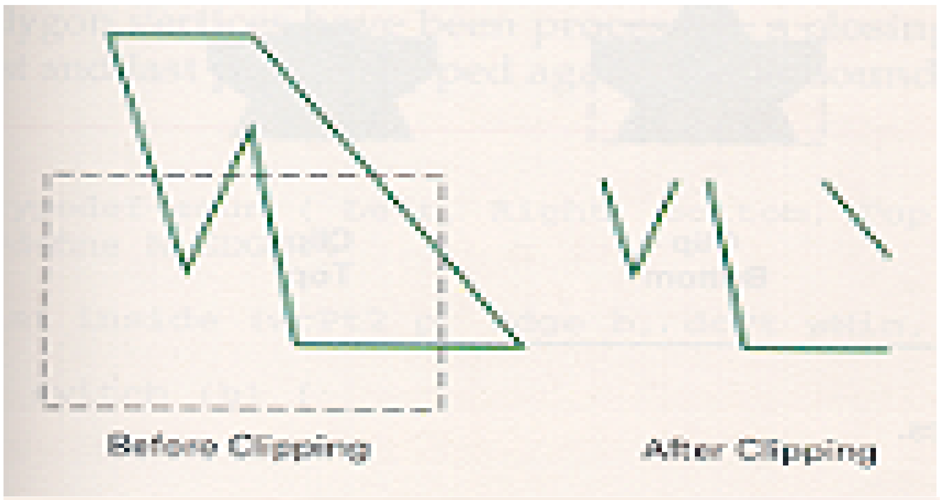
1. Outside Line Removal Test
   –A method that can be used to test lines total clipping is to perform the logical and operation with both region codes
   –Not 0000
2. Completely outside the clipping region!!
3. Lines that cannot be identified as completely inside or outside a clip window by this test.
4. Calculate Intersection Point
   – Using the slope-intercept form
   – Vertical Boundary, $y = y_1 + m (x – x_1)$
   – Horizontal Boundary

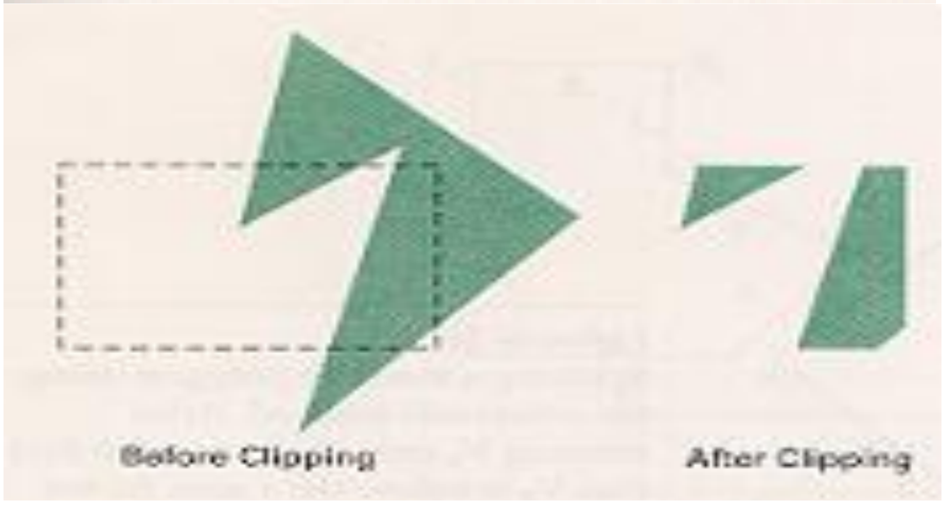
$$x = x_1 + \frac{y - y_1}{m}$$

$$m = (y_2 - y_1)/(x_2 - x_1$$



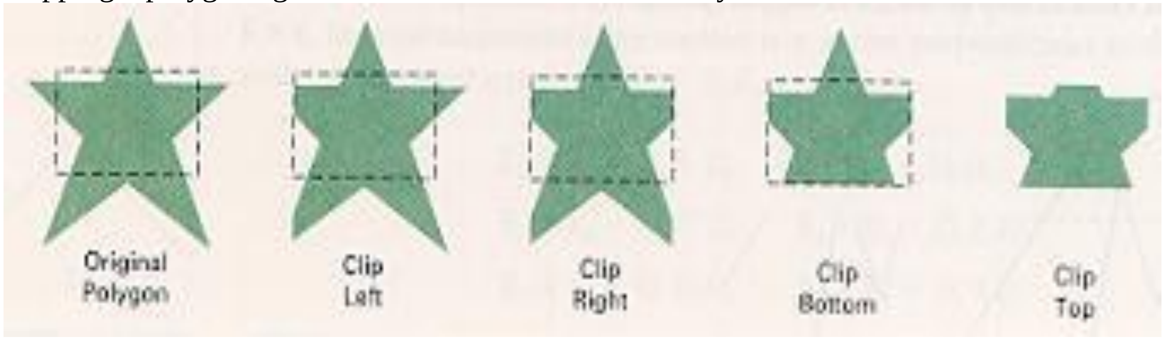
8. **Explain the various polygon clipping algorithm.**
POLYGON CLIPPING
Display of polygon processed by a line-clipping algorithm



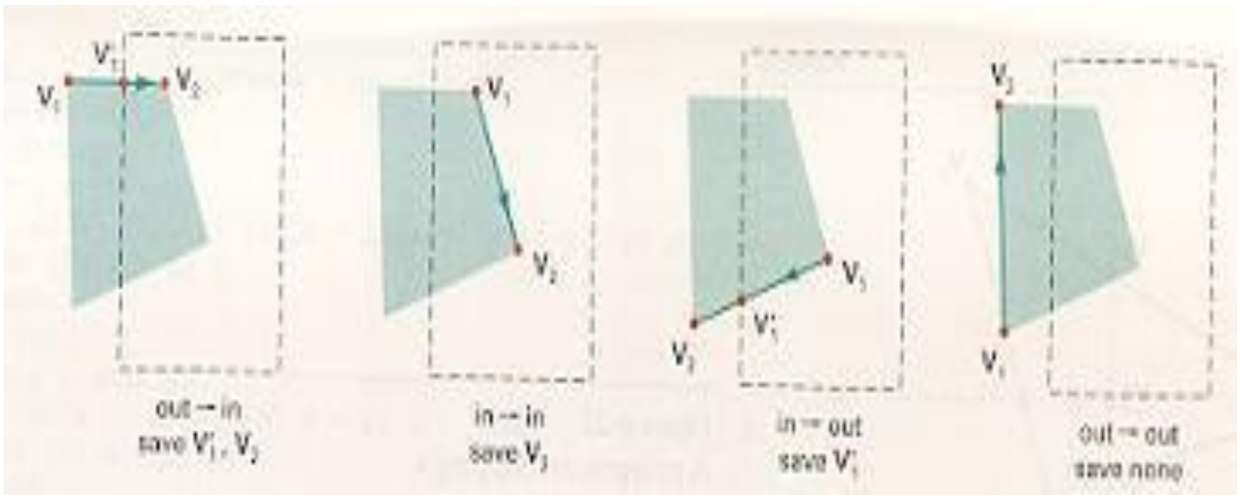


Sutherland-Hodgeman Polygon Clipping

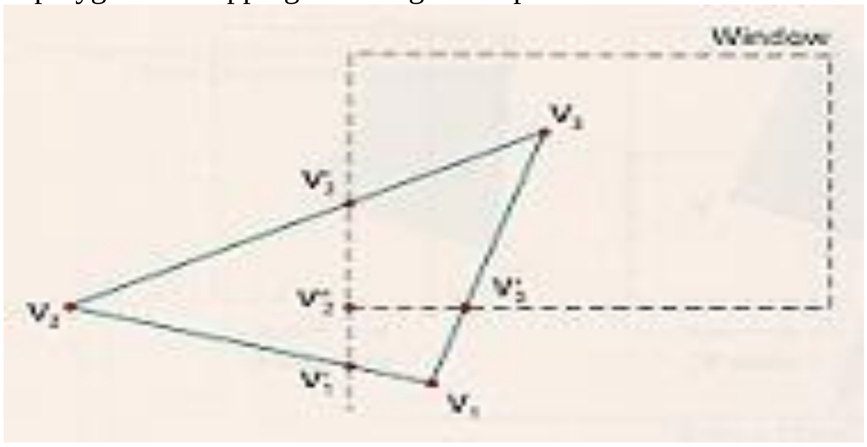
Clipping a polygon against successive window boundary



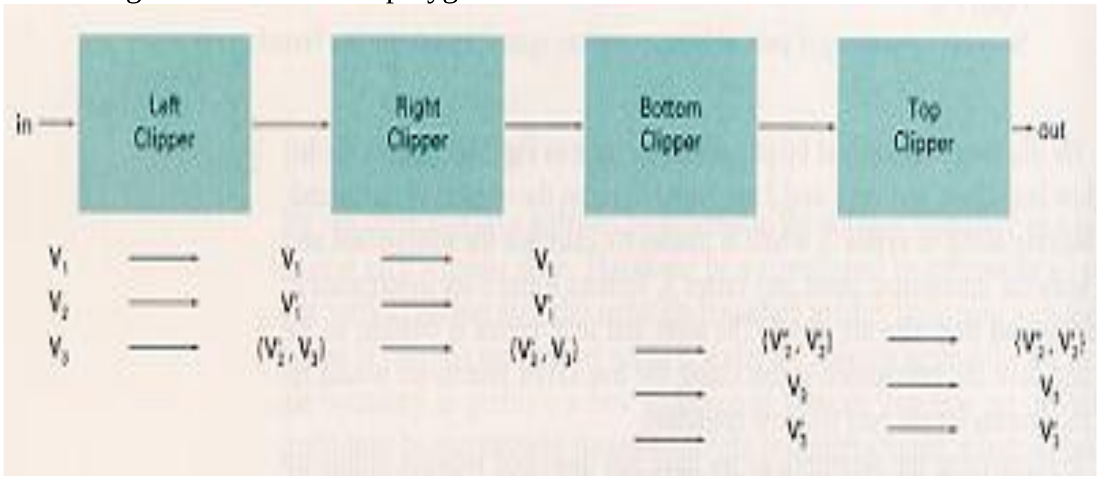
Successive processing of pairs of polygon vertices against the left window boundary



A polygon overlapping a rectangular clip window

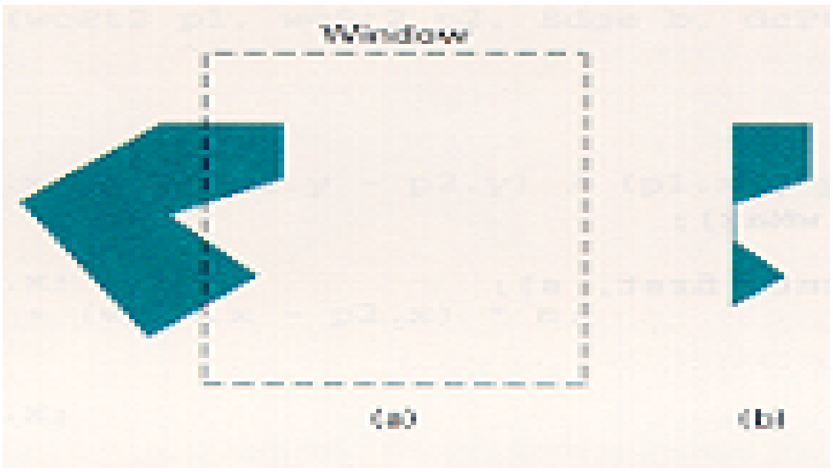


Processing the vertices of the polygon

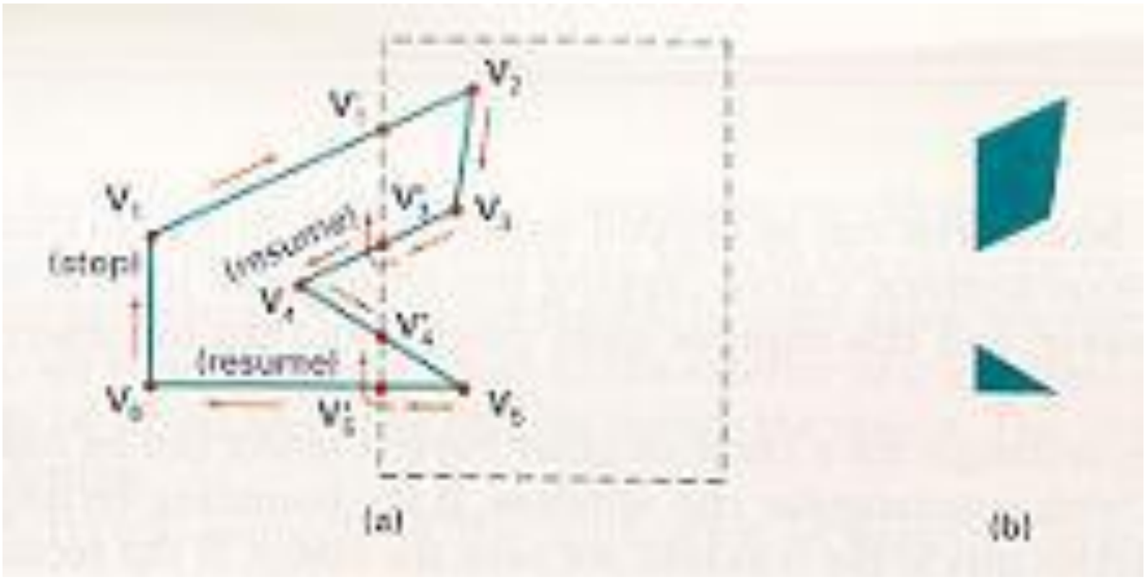


Weiler-Atherton Polygon Clipping

1. Problem of Sutherland-Hodgeman clipping
   –Displaying extraneous line



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



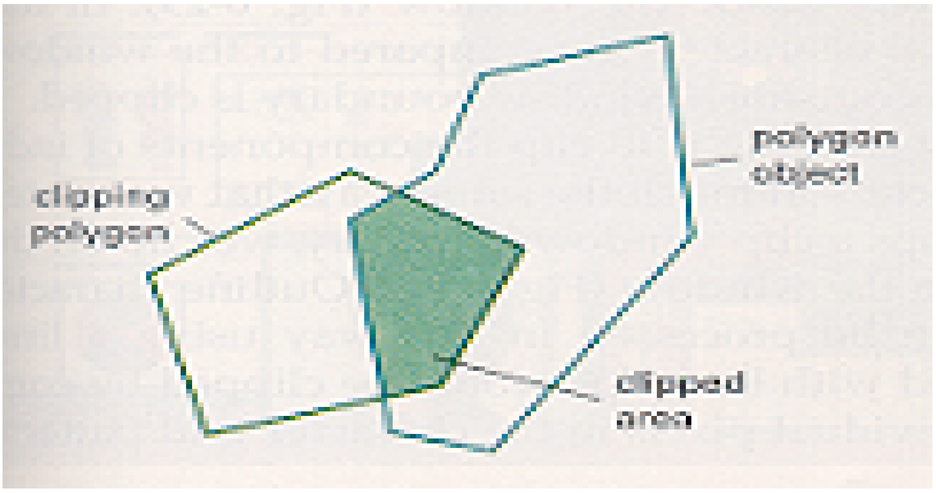
Other Polygon-Clipping Algorithm

1. Extending parametric line-clipping method

–Well suited for convex polygon-clipping

–Using region testing procedures

2. Clipping a polygon by determining the intersection of two polygon areas



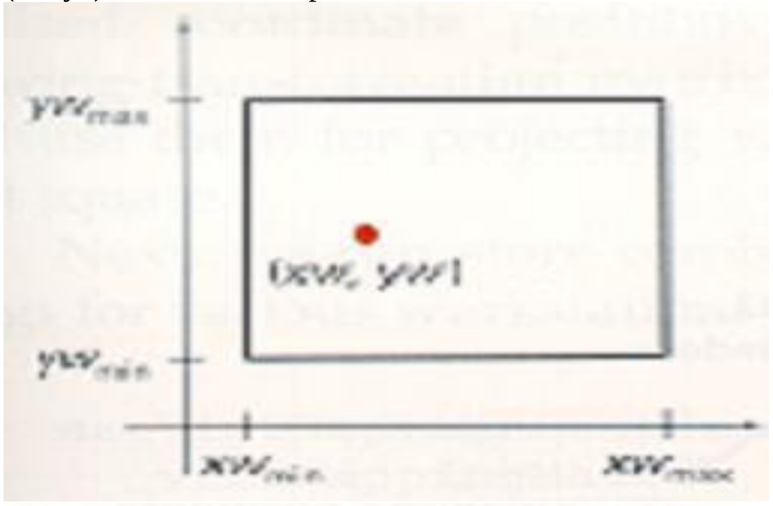
9. **Explain the window to viewport coordinate transformation..**

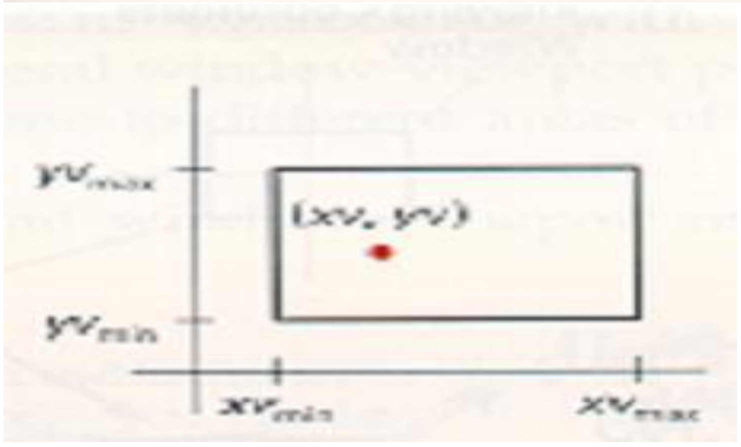
<u>WINDOW-TO-VIEWPORT COORDINATE TRANSFORMATION</u>

1. Window-to-viewport mapping ?

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





- To maintain the same relative placement

$$\frac{xv - xv_{\min}}{xv_{\max} - xv_{\min}} = \frac{xw - xw_{\min}}{xw_{\max} - xw_{\min}}$$

$$\frac{yv - yv_{\min}}{yv_{\max} - yv_{\min}} = \frac{yw - yw_{\min}}{yw_{\max} - yw_{\min}}$$

- Solving these expressions for the viewport position (xv, yv)

$$xv = xv_{\min}(xw - xw_{\min})sx$$

$$yv = yv_{\min}(yw - yw_{\min})sy$$

The scaling factors

$$sx = \frac{xv_{\max} - xv_{\min}}{xw_{\max} - xw_{\min}}$$

$$sy = \frac{yv_{\max} - yv_{\min}}{yw_{\max} - yw_{\min}}$$

Conversion sequence of transformation

1. Perform a scaling transformation using a fixed-point position of ($xw_{\min}$, $yw_{\min}$) that scales the window area to the size of the viewport
2. Translate the scaled window area to the position of the viewport

The way of character string mapping

–Maintaining character size

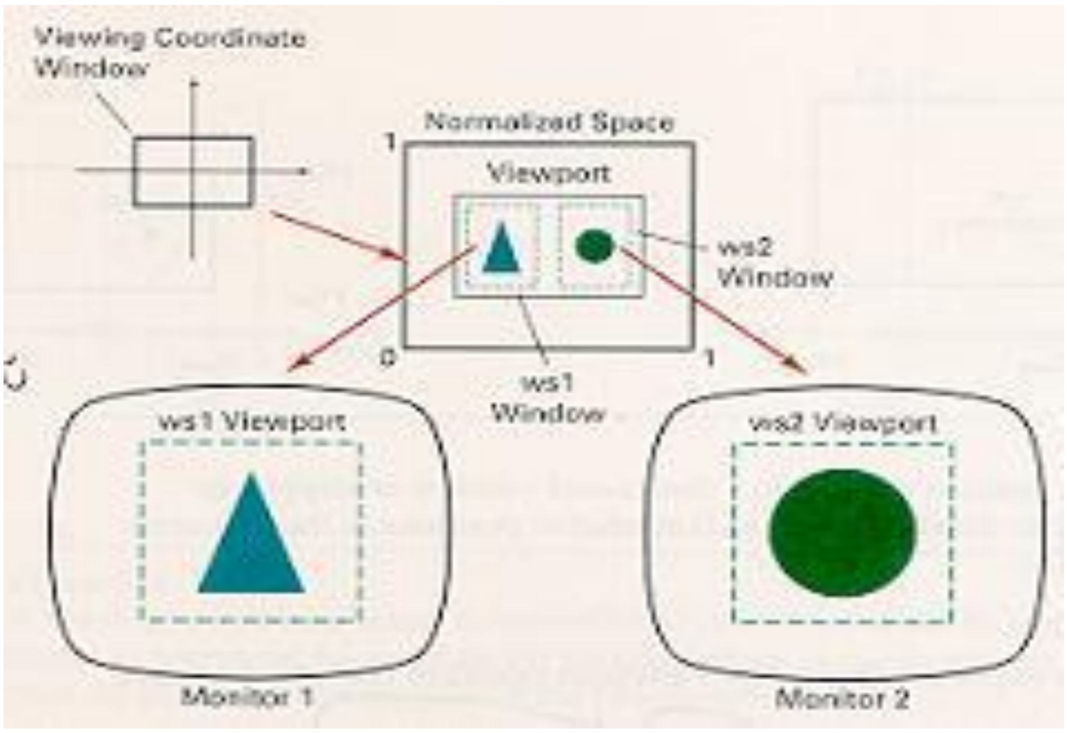
1. Using standard character fonts

–Changing character size

2. Using characters formed with line segments

Workstation transformation

3. –Opening any number of output devices in a particular application
4. –Performing another window-to-viewport transformation for each open output device
5. Mapping selected parts of a scene in normalized coordinates to different video monitors with Workstation transformation.



10. **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:

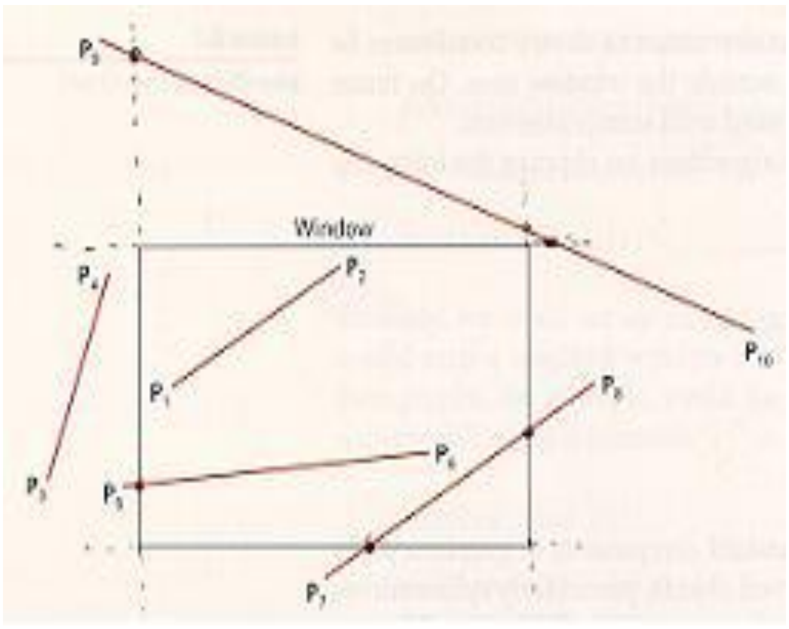
1. Assuming that the clip window is a rectangle in standard position
2. Saving a point P=(x, y) for display

$$xw_{min} <= x <= xw_{max}$$
$$yw_{min} <= y <= yw_{max}$$

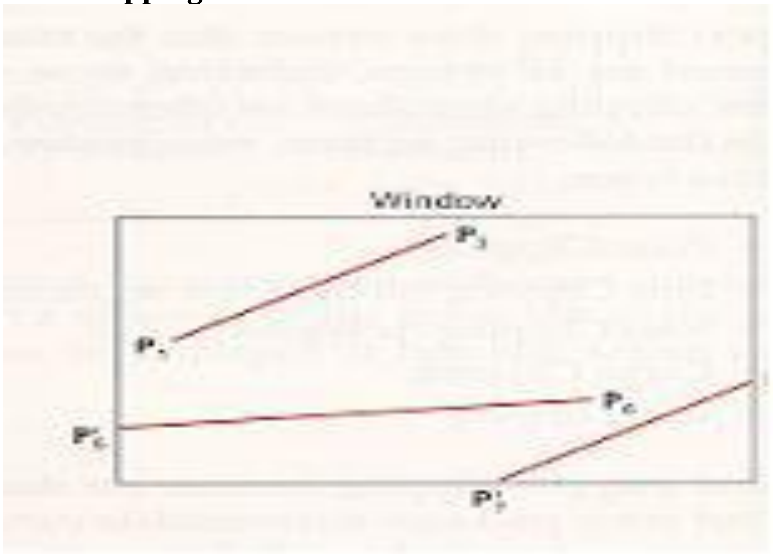
3. Appling Fields - Particles (explosion, sea foam)

Line Clipping:

Before Clipping



After Clipping



1. Parametric representation of Line segment with endpoints (x1, y1) and (x2, y2)

$x = x_1 + u(x_2-x_1)$

$y = y_1 + u(y_2-y_1)$; $0<=u<=1$

2. Exterior of the window

– Intersection with outside the range u

3. Interior of the window

– Intersection with inside the range u