Computer Graphics

Q.1 Illustrate the different types of Computer Graphics

Ans There are two types of computer graphics.

(i) **Raster graphics** => In Raster graphics pixels are used for an image to be drawn. It is also known as a bitmap image in which a sequence of images is into smaller pixels.

(ii) **Vector Graphics** => In vector graphics, mathmatical formula are used to draw different types of shapes. lines objects and so on.

Q.2 Explain frame Buffer

Ans A Frame Buffer is a portion of Random access memory (RAM) Containing a bitmap that drives a video display. It is a memory Buffer containing data represanting all pixels in a complete video frame. The frame Buffer is the size of the maximum image that can be displayed.

Q.3 Explain ~~line~~ DDA line Drawing algorithm.

Ans DDA stands for Digital Differential analiser it is an increamental method for scan conversion of line. In this method calculation is performed at each step but by using results of previous steps.

DDA algo => Given : Starting coordinate x_0, y_0
Ending Coordinate x_n, y_n

Step-① $\Delta x = x_n - x_0$

$\Delta y = y_n - y_0$ => $M = \frac{\Delta y}{\Delta x}$

Step-② Let current point x_p, y_p
next point x_{p+1}, y_{p+1}

find the next point by following the below three cases.

Three cases

- case-1 if $M < 1$ $\longrightarrow$ $x_{k+1} = x_k + 1$, $y_{k+1} = y_k + M$
- case-2 $M = 1$ $\longrightarrow$ $x_{k+1} = x_k + 1$, $y_{k+1} = y_k + 1$
- case-3 $M > 1$ $\longrightarrow$ $x_{k+1} = \frac{1}{M} + x_k$, $y_{k+1} = y_k + 1$

Step-③ Keep repeating Step-2 until the end point is reached.

Exa find intermediate point
given starting point $(2,2)$
ending point $(9,7)$

Soln

$\Delta x = 9 - 2 = 7$ $\qquad \Delta x > \Delta y$

$\Delta y = 7 - 2 = 5$

So number of steps $= 7$

$M = \frac{7-2}{9-2} = \frac{5}{7} < 1$

$7 \overline{)50}$ $.71$
49
10

follow case ①

Steps	x_0 , y_0	x_{k+1}	y_{k+1}
1	2 2	3	2.71
2		4	3.42
3		5	4.13
4		6	4.84
5		7	5.55
6		8	6.26
7		9	7

(4) Different b/w Random Scan System is different from Raster Scan.

Ans

Random Scan	Raster Scan
1. The resolution is higher	1. The resolution less
2. It is more expensive	2. It is less expensive
3. In Random scan it is easy to proceed with modification	3. In Raster it is difficult to do modification.
4. In Random we don't prefer interlacing	4. In Raster we prefer interlacing.
5. Exa of Random is: pen plotter	5. Exa of Raster is: TV sets
6. Difficult to fill solid pattern	6. ~~Difficult~~ easy to fill solid patten
7. In Random Scan ~~***~~ only an area of the screen with a picture is displayed	7. In Raster scan the entire screen is displayed.

Q.5 Discover and analyse the window to viewport normalization transformation. window lower left corner is (1,1), upper right corner is (3,5) and viewport lower left corner is (0,0) upper right corner is (12, 12)

Solu: Window → lower left corner is (1,1)
upper right " " is (3,5)
viewport → lower left corner is (0,0)
upper right corner is (12,12)

find $S_x = \dfrac{V_{x max} - V_{x min}}{W_{x max} - W_{x min}}$

$= \dfrac{12-0}{3-1} = 6$

$S_y = \dfrac{V_{y max} - V_{y min}}{W_{y max} - W_{y min}}$

$= \dfrac{12-0}{5-1} = 3$

$$N = \begin{bmatrix} 1 & 0 & V_{x min} \\ 0 & 1 & V_{y min} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -W_{x min} \\ 0 & 1 & -W_{y min} \\ 0 & 0 & 1 \end{bmatrix}$$

$$N = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 6 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

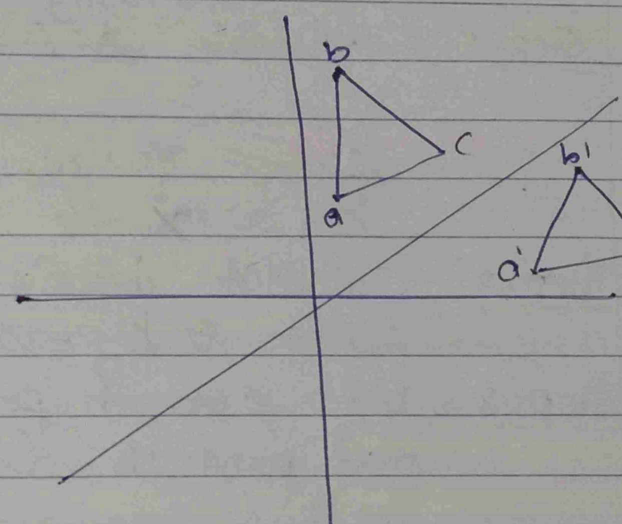
$$N = \begin{bmatrix} 6 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 6 & 0 & -6 \\ 0 & 3 & -3 \\ 0 & 0 & 1 \end{bmatrix}$$

Que No. 6 Devlop the mirror image of the triangle ABC about $Y = X$ axis with the help of matrices.

Ans Reflection about $y = x$ line The object may be reflected about line $y = x$ with the help of following tranformation matrices

First of all the object is rotated at 45. The direction of rotation is clockwise.

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



Q.7 Build the general form of the matrix for rotation about a point. P(h, k)

Ans Consider a point object O has to be rotated from one angle to another in a 2D plane.

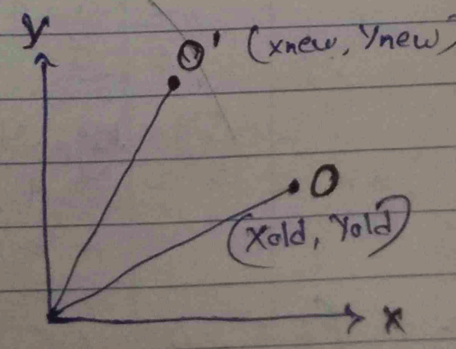
Let: • initial coordinate of the object O = (Xold, Yold)

• initial angle of object is = Φ

• Rotation angle = θ

• New cordinate of object is = (Xnew, Ynew)

① ~~Ant~~iclockwise Rotation



$$R = \begin{bmatrix} \cos\theta & \sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \times \begin{bmatrix} Xold \\ Yold \end{bmatrix}$$

② Anticlockwise

$$R = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \times \begin{bmatrix} Xold \\ Yold \end{bmatrix}$$

Q. 8 Explain Bresenham Line Algorithm and draw the line from (4, 4) and (9, 8)

Ans Bresenham line Drawing Algorithm attemts to generate the points b/w the starting and ending coordinate. This algo. is used to scan converting a line.

Algo :-

Given - Starting coordinate = x_0, y_0
ending coordinate = x_n, y_n

Step-1 calculate $\Delta x, \Delta y$

$$\Delta x = x_n - x_0$$
$$\Delta y = \cancel{x_n} - y_0$$

Step-2 Calculate decision parameter P_k

$$P_k = 2\Delta y - \Delta \cancel{x}$$

Step-3 Let current point is (x_k, y_k) and next point is (x_{k+1}, y_{k+1})

Two case

① ⇒ if $P_k < 0$
$P_{k+1} = P_k + 2\Delta y$
$x_{k+1} = \cancel{x_k} + 1$
$y_{k+1} = y_k$

② ⇒ if $P_k >= 0$
$P_{k+1} = P_k + 2\Delta y - 2\Delta$
$x_{k+1} = x_k + 1$
$y_{k+1} = y_k + 1$

Step-4 Keep repeating step-3 until the end point is reached.

find $\Delta x = x_n - x_0$
$= 9 - 4$
$= 5$

$\Delta y = \cancel{y_n} - y_0$
$= 8 - 4$
$= 4$

$P_k = 2\Delta y - \Delta x$
$= 8 - 5 = 3$

$P_k >= 0$ follow case -02

Suppose current point is (x_k, y_k) and next point is $(\cancel{x_{k+1}}, y_{k+1})$

P_k	P_{k+1}	x_{k+1}	y_{k+1}
		4	4
3	1	5	5
1	~~14~~ -1	6	6
-1 ~~14~~	7	7	6
7	5	8	7
5		9	8

$x_{k+1} = x_{k+1} = 4+1=5$

$= \cancel{9+1=10}$

$y_{k+1} = y_{k+1} = 4+1=5$

$= \cancel{18+1=19}$

$P_{k+1} = P_k + 2\Delta y - 2\Delta x$

$= 3+8-10 = 1$

$= \cancel{1+8-10} = -1$

$\cancel{14+8-5 = 9}$

$= 1+8-10 = -1$

Ans

$P_{k+1} = P_k + 2\Delta y$

$= -1 + 8$

$P_{k+1} = P_k + 2\Delta y - 2\Delta x$

$= 7+8-10 = 5$

Que. 10 Interpret the scan line method for hidden surface removal in three dimensanal object.

Ans ⇒ The scan line method is a technique used for hidden surface removal in three dimensonal 3-D objects in computer graphics. It helps to determine which surfaces are visible and should be rendered based on their position relative to the viewer's perspective.

Here's an interpretation of the scan line method and its workflow.

1. Object Represantation
2. Projection
3. Scan line Division
4. Sorting
5. Active Edge list
6. Edge table
7. Scan line processing
8. Edge Activation
9. Depth Comarision
10. AEL Updates.
11. Polygon fregement.

Q.11 Articulate about 2D. transformation in computer Graphics.

Ans 2 D transformation in computer graphics is a process of modifying and repositioning the existing graphics in two dimensions. It helps to change the position size and shape of the objects.

Types of transformations.

1. Translation
2. Scaling
3. Rotating
4. Reflection
5. Shearing.

Reflection => Reflection is a ~~king~~ kind of rotation ~~is~~ where the angle of rotation is 180' degree. The reflected object is always formed on the other side of mirror. Size of reflected object is same as original object.

Let => initial coordinate of object is:

$$O = (X_{old}, Y_{old})$$

new coordinat of object is:

$$O' = (X_{new}, Y_{new})$$

Reflection on x axis:

$$X_{new} = X_{old}$$
$$Y_{new} = Y_{old}$$

{homogeneous matrix form}

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ 1 \end{bmatrix}$$

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Reflection on y axis :

$x_{new} = -x_{old}$
$y_{new} = y_{old}$

homogeneous matrix form ⇒
$$\begin{bmatrix} x_{new} \\ y_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_{old} \\ y_{old} \\ 1 \end{bmatrix}$$

Q.13 Do you need to generate the full circumference of the circle using the algorithm,

Ans Yes it is possible to generate only a quadrant or an octant of a circle and then mirror or reflect those points to produce the rest of the circumference, This approach saves computational resoursec and improve. efficiency.
Generating a quadrant involves calculating the coordinates of points on one quarter of the circle.

Q.15 Explain Mid point circle Algorithm, Generate for one octant (90-45) with radius 7 units.

Ans The midpoint circle algo. helps us to calculate the perimeter points of a circle for the first octant.

solve
- initial point is (0, 7)
- decision perimeter = 1-R = 1-7 = -6
- Starting point coordinate is :

$x = 0, \; y = 7$

$P_k < 0$ follow case - 1

$x_{k+1} = x_{k+1}$
$y_{k+1} = y_k$, $P_{k+1} = P_k + 2x_{k+1} + 1$

P_k	P_{k+1}	x_{k+1}	y_{k+1}
		0	7
		1	7
-6	-5	2	7
-5	-2	3	7
-2	3	4	6
3	-4	5	6
-4	7	6	5
7	6		

$x_{k+1} = x_{k+1}$	y_{k+1}	$P_{k+1} =$ ~~$P_k + 2x_{k+1} + 2 +$~~	$P_{k+1} = P_k + 2(x_{k+1}) + 1$

$= -6 + 2\times0+1$

$= -5 + 2 + 1$

$= -2 + 2\times2+1$

$= 3 + 2\times3+1 - 2\times 7$

$= -4 + 10 + 1$

$= 7 + 10 + 1 - 12$

$\boxed{x_{k+1} \geq y_{k+1}}$ Ans

Q.16 Given a triangle with vertices (0,0), (2,0), (1,1). Reflect this triangle about x axis, y axis and $x = 2$, $y = 1$

Ans Reflection along x axis

A (0,0) ⇒ $x_{old} = x_{new} = 0$

$y_{new} = -y_{old} = 0$

B. (2,0) ⇒ $x_{new} = x_{old} = 2$

$y_{new} = -y_{old} = 0$

C. (1,1) = $x_{new} = x_{old} = 1$

$y_{new} = -y_{old} = -1$

Reflection along y axis

A(0,0) $x_{new} = 0$, $y_{new} = 0$	B (2,0) $x_{new} = -2$, $y_{new} = 0$	C (1,1) $x_{new} =$ -1, $y_{new} =$

$x \Rightarrow (2a-x, y)$
$y \Rightarrow (x, 2a-y)$

Reflection for $x=2$	Reflection for $y=1$
$A(0,0) \Rightarrow (x,y) = (2\times2-0, 0) = (4,0)$	$A(0,0) = (x,y) = 0, (2\times1-0) = (0,2)$
$B(2,0) = (x,y) = (2\times2-2, 0) = (2,0)$	$B(2,0) = (x,y) = (2, 2\times1-0) = (2,2)$
$C(1,1) = (x,y) = (2\times2-1, 1) = (3,1)$	$C(1,1) = (x,y) = (1, 2\times1-1) = (1,1)$

Ans.

Q.17 Draw Neat diagram for CRT and Explain CRT and analyze its component.

Ans CRT ⇒ CRT stands for cathode Ray tube. CRT is a technology used in traditional computer monitors and telivisions. The image on CRT display is created by firing electrons from the back of the tube of phosphorus from the ~~back of the tube~~ located towards the front of the screen. Once the electron heats the phosphorus they light up and they are projected on a screen.

Component of CRT

1. Electron Gun - It is used to produce a strain of electron.
2. Focussing/Anodes - These are used to produce a narrow and sharply focus beam of e-
3. Deflection yoke - It is used to control the path of e- beam.
4. Evacuted Glass of Envelop :-

Q.18 Justify the uses of A-buffer method and scan line method.

Ans - **A-Buffer** method in computer graphics is a general hidden face detection mechanism suited medium scale virtual memory computers. It is also know as anti-aliased buffer.

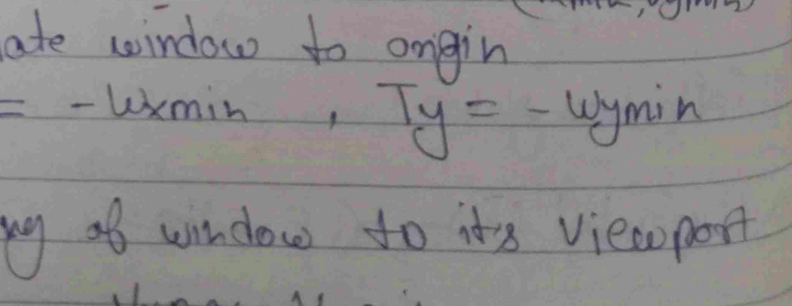
- It improves anti-aliasing
- It handles transparency and complex scenes.
- Stores all visible fragments per pixel

Scan line method: It is an image space algorithm, It is an algorithm for visible surface determination in 3D computer graphics. It processes one line at a time. It uses the concept of coherence.

- It is efficient for polygon filling.
- It is useful for hidden surface removal.

Q.20 Develop the procedure for window to Viewport Coordinate transformation in 2D.

Ans



Step 1 Translate window to origin

$$T_x = -W_{xmin}, \quad T_y = -W_{ymin}$$

Step-2 Scalling of window to it's Viewport

$$S_x = \frac{V_{xmax} - V_{xmin}}{W_{xmax} - W_{xmin}}$$

$$S_y = \frac{V_{ymax} - V_{ymin}}{W_{ymax} - W_{ymin}}$$

Step-3 again translate viewport to it's current position.

$$T_x = V_{x min}$$
$$T_y = V_{y min}$$

matrix form

$$T = \begin{bmatrix} 1 & 0 & V_{xmin} \\ 0 & 1 & V_{ymin} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -W_{xmin} \\ 0 & 1 & -W_{ymin} \\ 0 & 0 & 1 \end{bmatrix}$$

Q.21 Classify different types of polygon Tables and write advantage and disadvantage each of them.

Ans polygon tables are used in computer graphics to represent and store information about polygon in a scene. There are several types of polygon tables

① Edge table ⇒

Advantage
- Efficient storage.
- Quick access to edges.

Disadvantage
- Limited information
- Additional processing required.

② Polygon Edge Table ⇒

Advantage
- Stores both polygon and edges.
- Supports vertex attributes.

Disadvantage
- Increased memory requirements.
- Slower edge retrieval.

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③ face Table =>

Advantage => • Stores complete polygon information
• Efficient access to polygon.

Disadvantage => • Higher memory consumption.
• Increased proccessing overhead.

④ Scan line Conversion Table

Advantage => • Specially disigned for scanline based rendering.
• Support efficient polygon rasterizati

Disadvantage => • Limited functionality.
• Complexity.

Q.29 Compare DDA Line and Breshem algo.

Ans

DDA	Bresenham
① It is stands for digital Differential analyzer	① It has no full form
② DDA less efficient	② It is more efficient
③ Calculation speed is less	③ Calculation speed is fast
④ It is costlier than Bresenham	④ It is less expensive
⑤ Calculation is complex	⑤ Calculation is simple

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Q.30 Difine following term ÷

Ans (1) Parralles Projection ⇒ Parallel projection use to display picture in it's true shape and size. It is used by architects and engineers for creating working drawing the object. for complete representation of the object we require two or more view of an object using different planes.

(2) Perpestive Proyection ⇒ In this proyection the center of proyection is at finite distance from proyection plane. This proyection produces realistic views. ~~but~~ It is used by architects and engineer ~~to~~ for drawing three dimension scene. In perspective proyection lines are not remain parralled. The lines converge at a point called a center of proyection.

(3) Vanishing Point ⇒ It is the point where all lines will appear to meet There can be one point, two point and three point perspective.

one point - There are only one vanishing point
Two point - There ~~are~~ are two vanishing point.
Three point - There are three vanishing point.

(4) Proyection referrence point ⇒ In perspective proyection lines of proyection do not remain parralled they all are converge at a point called center of proyection or proyection referance point.

(5) Orthographic Proyection ⇒ when proyectors are perpendicular to view plane then it is known as orthographic prooyection. It is a tipe of parralles proyection.

(6) Orthographic Oblique Projection. => It is a kind of parallel projection. In oblique projection we can view the object better than orthographic projection. It has two type.
(1) Cavalier (2) Cabinet.

Q. 31 Compare ~~and~~ b/w Bezier and B spline curve.
Ans Bezier Curve => These curves specified with boundary conditions with a characterizing matrix. A Bezier curve section can be filled ~~with~~ by any number of Control ~~Box~~ Point.

B-Spline Curve => B spline is a basic function that contain a set of control point. B spline curve specified by Berstien basis function that has limited flexibility.

Bezier	B-Spline
• The Bezier curve has the global control over the curve.	• The B-Spline curve has the local control over the curve.
• The Computation of Bezier curve is easy	• The Computation of B spline curve is tough

Q. 32 function of control grid in CRT.
Ans The Control greed in a CRT used to control the intensity of e⁻ beam and brightness.

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Q.34 Explain Horizontal and Vertical Retrace.

Ans Horizontal Retrece => Horizontal retrece is the period when the electron beam returns from the right to the left side of a CRT display after completing a Scan line.

Vertical retrece => Vertical retrace is when the beam moves from the bottom to the top of the screen to strat drawing the next frame.

Q.36 Define basic transformations with homogeneous coordinate representation.

Ans In homogeneous coordinate system two-dimensional coordinate positions (x, y) are represented by triple coordinate. Homogeneous coordinate generally used in design and construction applications.

Exa of homogeneous coordinates.

(1) Tranlation = $\begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix}$

(2) Scaling = $\begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$

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

(4) Reflection (x axis) = $\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

(5) Shearing (x direction) = $\begin{bmatrix} 1 & 0 & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Shearing (y direction) = $\begin{bmatrix} 1 & Sh_y & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Q.33 Develop a procedure based on a Back-Face detection technique for identifying all the visible faces.

Ans Back face detection is a common technique used in computer graphics to determine which faces of a 3D object are visible and should be rendered. Here is a procedure :-

Step ① Define the viewer's position.
Step ② Calculate the surface normal for each face.
Step ③ Determine the viewing direction.
Step ④ Perform dot product calculations.
Step 5 Apply back face culling.
Step 6 Provide visible faces.

Depth Buffer method => The depth buffer method also known as Z-buffer method is a popular algorithm used in computer graphics to handle hidden surface removal. It involves comparing the depth values of pixels to determine visibility.

Q.38 Explain viewing pipeline.

Ans The viewing pipeline is a sequence of stages in computer graphics. It is also known as graphics pipeline. It is used represent 3D object on 2D plane. The stages includes:- Modeling, Camera position, Projection, Clipping Rasterization Shading, Texturing and Compositing.

Q. 43 Explain various applications of computer graphics

Ans Computer graphics is an art of drawing picture on computer with the help of programming.

Application of C.G (1) Computer graphics are also used in the field of commertial art.

(2) Entertainment => It is commonly used in making motion picture.

(3) Printing tehnology => It is used for printing technology

(4) Educational software => It is used in development of Educationalt field.

(5) Visualization.

Q. 45 Explain 3-D transformation and it's type.

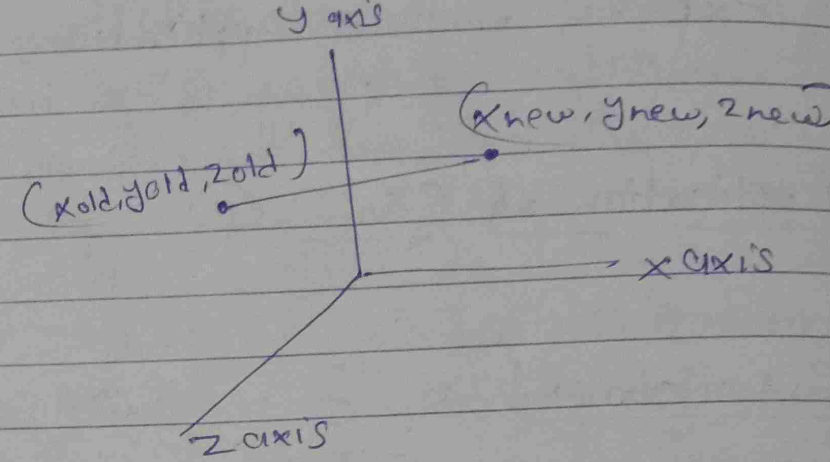
Ans 3-D transformation is a process of modifying and Repositioning the existing graphics. 2-D takes place on 3-Dimentional plane. 3D is mare complex than 2D

Types of transformation

1. Translation
2. Rotation
3. Scaling
4. Reflection
5. Shearing

Translation It is a process of moving an object from one ~~position~~ to another position in ~~3~~ 3 Dimention.

[52, 61]



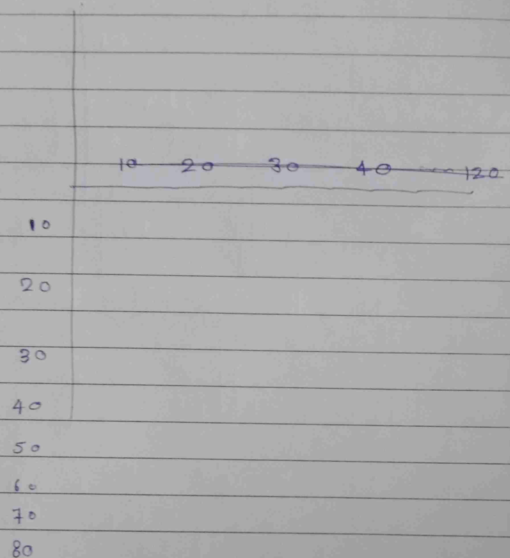
$X_{new} = X_{old} + T_x$
$Y_{new} = Y_{old} + T_y$
$Z_{new} = Z_{old} + T_z$

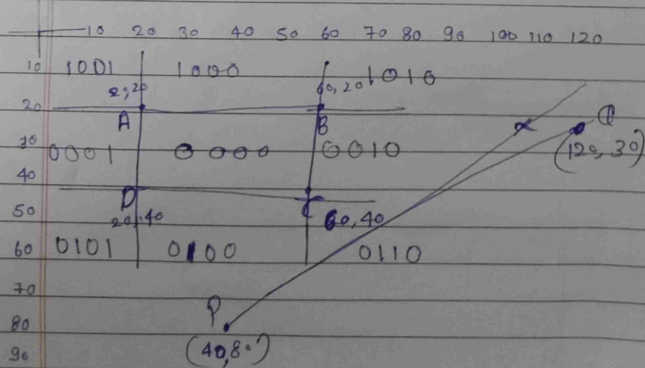
<u>matrix form</u>

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

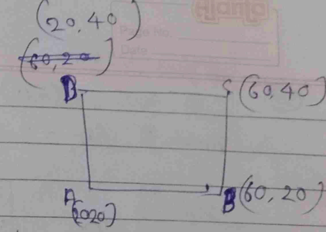
<u>Q.55</u> Explain Pixel and how it's different from a point.

<u>Ans</u> The full form of the pixel is "Picture Element". It is also known as "PEL", Pixel is the smallest element of an image on a computer display.





(23) Given window



Line PQ is not visible.

(24) Bresenham line clipping algorithm.

Point (2,1) (8,6)

Soln Find

$\Delta x = x_n - x_0 = 6$

$\Delta y = y_n - y_0 = 5$

$P_K = 2\Delta y - \Delta x$

$= 10 - 6 = 4$

$\boxed{P_K \geq 0}$ case (2)

$P_{K+1} = P_K + 2\Delta y - 2\Delta x$

~~= 4+10 = 14~~

~~= 14+10 = 24~~

~~14 − 12 = 2~~

~~2+10−12 = 0~~

~~0+10−12~~

~~−2+10 = 8~~

6+10−12

PK	PK+1	XK+1	YK+1
		2	1
4>0	2	3	1
2>0	0	4	1
0≥0	−2	5	2
−2	8	6	3
6	4	7	3

$P_{K+1} = 4 + 10 - 12 = 2$

$2 - 2 = 0$

$0 + 10 - 12$

$-2 + 10 = 8$

$-4 + 10$

$8 + 10 - 12 = 6$

$6 + 10 - 12 = 4$

0	0	2	1
4	2	3	2
2	0	4	3
0	−2	5	4
−2	[illegible]	6	4 5
[illegible] 8	[illegible]	7	

PK	PK+1	XK+1	YK+1
6	4	8	6

Ans

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Square vertices

(25) $A(0,0)$, $B(1,0)$, $C(1,1)$, $D(0,1)$

$Sh_x = 2$, $Sh_y = 3$

Sol

x axis

$$\begin{pmatrix} x_{new} \\ y_{new} \end{pmatrix} = \begin{bmatrix} 1 & Sh_x \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_{old} \\ y_{old} \end{bmatrix} = \cancel{x_{old}} \; y_{old}$$

$= \cancel{Sh_x(x_{old})}$

$= x_{old} + Sh_x\, y_{old} + \cancel{0 + y_{old}}$

$y_{new} = \cancel{y_{old} + Sh_y\, x_{old}}\; y_{old}$

y axis

$x_{new} = x_{old}$

$y_{new} = y_{old} + x_{old}\, Sh_y$

Sol x axis

Point $A(0,0)$

$x_{new} = 0 + 0 \times 2$
$= 0$

$y_{new} = 0$

Point $B(1,0)$

$x_{new} = x_{old} + y_{new} Sh_x$
$= 1$

$y_{new} = 0$

Point $C(1,1)$

$x_{new} = 1 + 1 \times 2$
$= 3$

$y_{new} = 1$

Point $D(0,1)$

$x_{new} = 0 + 2 \times 1 = 2$

$y_{new} = 1$

x, y direction $A(0,0)$

$$\begin{pmatrix} x_{new} \\ y_{new} \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & Sh_y & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_{old} \\ y_{old} \\ 1 \end{pmatrix}$$

$$= \begin{bmatrix} 1 & 3 & 0 \\ 2 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

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(27) Calculate pixel location

centre of circle $(0,0)$, Radius $= 6$

Let initial coordinate of circle (x_0, y_0)

$x_0 = 0$

$y_0 = 6$

$P_k = 1 - R = 1 - 6 = -5$

$\boxed{P_k < 0}$ follow case (2)

P_k	P_{k+1}	x_{k+1}	y_{k+1}
		0	6
-5	-4	1	6
-4	-1	2	6
-1	4	3	6
4	11	4	5
11	14	5	4

Ans

$P_k < 0$

$P_{k+1} = P_k + 2(x_{k+1}) + 1$

$-5 + 2 \times 0 + 1 = -4$

$-4 + 2 \times 1 + 1 = -1$

$-1 + 2 \times 2 + 1 = 4$

$P_{k+1} \geq 0$

$P_{k+1} = P_{k+1} + 2x_{k+1} - 2y_{k+1} + 1$

$= 4 + 2 \times 3 - 2 \times 6 + 1$

$4 + 6 - 12 + 1$

$= 11 + 10 - 8 + 1 = 14$

(28) Use transformation matrices to carry out a 45 degree rotation A(0,0), B(1,1), C(5,2) about (-1,-1) followed by reflection with respect to y ax.

Ans

$$P = T_1 R T_2 = \begin{bmatrix} 1 & 0 & -x_p \\ 0 & 1 & -y_p \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & x_p \\ 0 & 1 & y_p \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & -(-1) \\ 0 & 1 & -(-1) \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

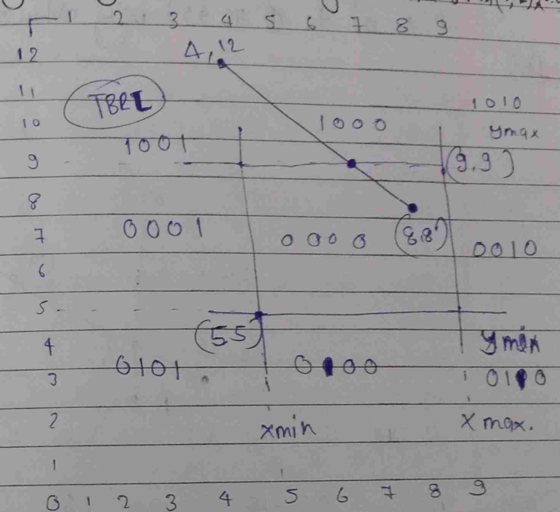
$$= \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & -1 \\ 1/\sqrt{2} & 1/\sqrt{2} & (2/\sqrt{2})-1 \\ 0 & 0 & 1 \end{bmatrix}$$

now multiply the resultant matrix with the triangle matrix

$$P' = PT = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & -1 \\ 1/\sqrt{2} & 1/\sqrt{2} & (2/\sqrt{2})-1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 1 & 5 \\ 0 & 1 & 2 \\ 1 & 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} -1 & -1 & (3/\sqrt{2})-1 \\ (2/\sqrt{2})-1 & (4/\sqrt{2})-1 & (9/\sqrt{2}) \\ 1 & 1 & 1 \end{bmatrix}$$ Ans

Q.35 window size from (5,5), (9,9) clip the line using clipping algorithm for a given line from (4,12) (8,8)



Point (4,12), (8,8)

$x = \frac{1}{m}(y_{max} - y_1) + x_1$ | $m = \frac{-4}{4} = -1$

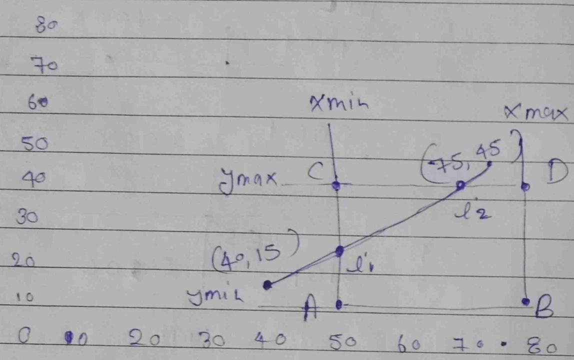
$= -1\,(9 - 12) + 4$

$\boxed{x = -9 + 12 + 4 = 7}$

intersection point is $i = (7, 9)$ Ans

Q:37) ABCD is a rectangular window with A(50,10), B(80,10), C(50,40), D(80,40). clip the line P(40,15) to Q(75,45) using Cohen Sutherland algo.

Ans



Solu: $m = \frac{45-15}{75-40} = \frac{30}{35} = \frac{6}{7}$

find intersection points I_1, I_2

$I_1 = ?$ $I_2 = ?$ (40,15), (75,45)

$I_1 \Rightarrow y = m(x_{min} - x_1) + y_1$

$= \frac{6}{7}(50-40) + 15$

$y = \frac{6}{7}(10) + 15 = \frac{60+105}{7} = \frac{165}{7}$

$(x, y) = (50, 165/7)$

$I_2 \Rightarrow x = \frac{1}{m}(y_{max} - y_1) + x_1$

$= \frac{7}{6}(45-15) + 40 = \frac{7}{6}(\cancel{30}\,5) + 40$

$x = 35 + 40 = 75$

(75,45)

39) window to viewport normalization transformation

window lower left corner (1,1)

upper right corner (3,5)

viewport lower left corner (0,0)

upper right corner (1/2, 1/2)

Sol: find S_x and S_y

$$S_x = \frac{V_{xmax} - V_{xmin}}{W_{xmax} - W_{xmin}} = \frac{(\frac{1}{2} - 0)}{(3-1)} = \frac{\frac{1}{2}}{2} = \frac{1}{4}$$

$$S_y = \frac{V_{ymax} - V_{ymin}}{W_{ymax} - W_{ymin}} = \frac{(\frac{1}{2} - 0)}{(5-1)} = \frac{1}{8}$$

$T_x = -W_{xmin}$, $T_y = -W_{ymin}$

$$N = \begin{bmatrix} 1 & 0 & V_{xmin} \\ 0 & 1 & V_{ymin} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -W_{xmin} \\ 0 & 1 & -W_{ymin} \\ 0 & 0 & 1 \end{bmatrix}$$

$$N = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{1}{4} & 0 & 0 \\ 0 & \frac{1}{8} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

$$N = \begin{bmatrix} 1/4 & 0 & 0 \\ 0 & 1/8 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

$$N = \begin{bmatrix} 1/4 & 0 & -1/4 \\ 0 & 1/8 & -1/8 \\ 0 & 0 & 1 \end{bmatrix}$$ Ans

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(46) A polygon has four vertices located at A(20,10), B(60,10), C(60,30) and D(20,30) apply scaling transformation to double the size of polygon with point. A located on the same place.

Sol: In this case we need to double the size of polygon, so the scaling factor would be 2.

Lets apply the scaling transformation to each vertex of the given polygon.

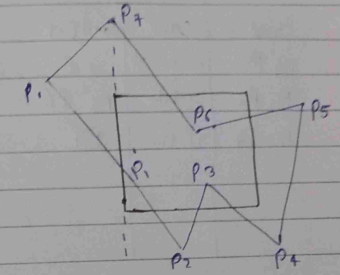
- A(20,10) A remains on the same place
- B(60,10) multiply the x coordinate by "2" then B(120,10)
- C(60,30) multiply the ~~x coordi~~ x, y coordinat by "2" then C(120,60)
- D(20,30) multiply the y coordinat by 2 then D(20,60)

New vertice after scalling of polygon.

A(20,10)
B(120,10)
C(120,60)
D(20,60)

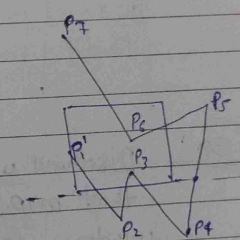
(3) in-in (4) out-out

(47) Apply Sutherland Hodgeman polygon clipping algo.



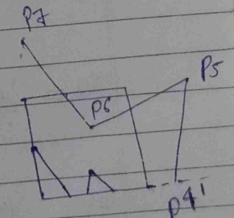
(1) clipping against left edge

vertex	case	output
P1 P2	out in	P1' P2
P2 P3	in in	P3
P3 P4	in in	P4
P4 P5	in in	P5
P5 P6	in in	P6
P6 P7	in in	P7
P7 P8	in out	P7'



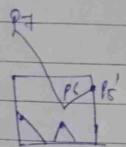
(2) clipping against ~~left~~ Bottom edge

vetrex	case	output
P1' P2	in out	P1''
P2 P3	out in	P2' P3
P3P4	in out	P3'
P4 P5	out in	P4' P5
P5 P6	in in	P6
P6 P7	in in	P7



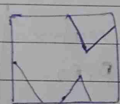
③ Clipping against Right edge.

vertex	case	output
P4' P5	out-out	null
P5 P6	out in	P5' P6
P6 P7	in in	P7



④ Clipping against top edge

vertex	case	output
P5' P6	in in	P6
P6 P7	in out	P6'



Q. 50 Discover window to viewport normalization that maps a window where
window lower left corner = (1,1)
upper right corner = (3,5)
viewport lower left corner = (0,0)
upper right corner = (1/2, 1/2)

$$S_x = \frac{V_{xmax} - V_{xmin}}{W_{xmax} - W_{xmin}} = \frac{1/2}{2} = 1/4$$

$$S_y = \frac{V_{ymax} - V_{ymin}}{W_{ymax} - W_{ymin}} = \frac{1/2}{4} = 1/8$$

$$N = \begin{bmatrix} 1 & 0 & V_{xmin} \\ 0 & 1 & V_{ymin} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -W_{xmin} \\ 0 & 1 & -W_{ymin} \\ 0 & 0 & 1 \end{bmatrix}$$

$$N = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1/4 & 0 & 0 \\ 0 & 1/8 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$$

$$N = \begin{bmatrix} 1/4 & 0 & -1/4 \\ 0 & 1/8 & -1/8 \\ 0 & 0 & 1 \end{bmatrix}$$

Ans

(41) window left head corner = (-3,1)

right head " " = (2,6)

(42) Radius = 10,

center of the circle is (0,0)

Sol: Current poin x_0, y_0

$x_0 = 0$

$y_0 = 10$

$P_K = 1 - R = -9$

$P_K < 0$ follow case-1

PK	PK+1	xK+1	yK+1
		0	10
-9	-8	1	10
-8	-5	2	10
-5	0	3	10
0	-13	4	9
-13	-4	5	9
-4	7	6	9
7	2	7	8
2	1	8	9

$P_K < 0$

$P_{K+1} = P_K + 2x_{K+1} + 1$

$= -9 + 2\times0 + 1 = -8$

$-8 + 2\times1 + 1 = -5$

$-5 + 2\times2 + 1 = 0$

$-13 + 2\times4 + 1 = -4$

$-4 + 2\times5 + 1 = 7$

$P_K \geq 0$

$P_{K+1} = P_K + 2x_{K+1} + 1 - 2y_{K+1}$

$= 0 + 2\times3 + 1 - 20$

$= -13$

$= 7 + 2\times6 + 1 - 2\times9$

$= 20 - 18 = 2$

$= 2 + 2\times7 - 8\times2 + 1$

$= 17 - 16$

(44) Rotate a triangle vertices are: $A(2,3,1), B(3,4,5), C(5,6,7)$ about y axis.

Sol (Rotation in Y axis) Let $\theta = 45°$

$x_n = x_0 \cdot \cos\theta + z_0 \sin\theta$

$y_n = y_0$

$z = z_0 \cdot \cos\theta - x_0 \sin\theta$

Point (A) (2,3,1)

$x_{new} = x_{old}\cos\theta + z_{old}\sin\theta$

$y_{new} = y_{old}$

$z_{new} = z_{old}\cos\theta - x_{old}\sin\theta$

$x_{new} = 2\times\frac{1}{\sqrt2} + 1\times\frac{1}{\sqrt2} = \frac{3}{\sqrt2}$

$y_{new} = 3$

$z_{new} = 1\times\frac{1}{\sqrt2} - 2\times\frac{1}{\sqrt2} = \frac{-1}{\sqrt2}$

Point (B) (3,4,5)

$x_{new} = 3\times\frac{1}{\sqrt2} + 5\times\frac{1}{\sqrt2} = \frac{8}{\sqrt2} = 4\sqrt2$

$y_{new} = 4$

$z_{new} = 5\times\frac{1}{\sqrt2} - 3\times\frac{1}{\sqrt2} = \frac{2}{\sqrt2} = \sqrt2$

Point (C) (5,6,7)

$x_{new} = 5\times\frac{1}{\sqrt2} + 7\times\frac{1}{\sqrt2} = \frac{12}{\sqrt2}$ $6\sqrt2$

$y_{new} = 6$

$z_{new} = 7\times\frac{1}{\sqrt2} - \frac{5}{\sqrt2} = \frac{2}{\sqrt2} = \sqrt2$