Unit-1

Q1) Difference between Random Scan and Raster Scan display?

Ans:-

Base of Difference	Raster Scan Display	Random Scan Display
Electron Beam	The electron is swept across the screen one row at a time from top to bottom.	The electron beam is directed only to the parts of screen where a picture is to be drawn
Resolution	It's resolution is poor because Raster system in contrast produces zig-zag lines that are plotted as discrete point sets	It's resolution is good because it produces smooth line drawing because CRT beam directly the line path.
Picture Definition	Picture defination is stored as a set of intensity values for pixel makes it all screen points called pixel in a refresh buffer area.	Picture Defination is stored as a set of line drawing instrusction in a display file
Draw an image	Screen point or pixels are used to draw an image.	Mathematical function are used to draw an image.

Q2) Define the term Bitmap, Pixel map and Resolution, also describe function of CRT.

Ans Bitmap:- A method by which a display space (such as a graphics image file) is defined, including the colour of each of its pixels (or bits). A GIF is an example of a graphics image file that has a bitmap.

Pixel map :- A bitmap with more than one bit (binary digit) assigned to each pixel, allowing for multiple shades or colors.

Resolution :- It indicates the number of pixels that are displayed per inch for an image (or pixels per centimeter).

CRT is a evacuated glass tube in which images are produced when an electron beam strikes a phosphorescent surface. It modulates, accelerates, and deflects electron beam(s) onto the screen to create the images.

Q3) Using Bresenham's line drawing algorithm find a list of activated pixels for the line (5,5) to (13,9)?

Ans :- Step 1 :-

$x1 = 5$, $y1 = 5$ and $x2 = 13$, $y2 = 9$.

Step 2 :-

$\Delta x = |13-5| = 8$ $\Delta y = |9-5| = 4$

Step 3 :-

$x = 5$, $y = 5$

$\Rightarrow P_k = 2\Delta y - \Delta x = 0$

Tabulating the results of each iteration in the step 4 through 10

i	Plot	x	y	P_k
		5	5	0
1	(5,5)	6	6	-8
2	(6,6)	7	6	0
3	(7,6)	8	7	-8
4	(8,7)	9	7	0
5	(9,7)	10	8	-8
6	(10,8)	11	8	0
7	(11,8)	12	9	-8
8	(12,9)	13	9	0
9	(13,9)	14	10	-8

Q4) Given a clipping window A(20,20), B(60,20), C(60,40), D(20,40) using cohen sutherland algorithm find visible portion of the line segment joining the points P(40,80) and Q(120,30).

Ans:- This line is completely outside the window

Q5) Give the conceptual framework for interactive graphics. Enumerate the advantages of interactive graphics.

Ans:- Conceptual framework for interactive graphics has the following elements:

- Graphics Library - Between application and display hardware there is graphics library/API
- Application Program - An application program maps all application objects to images by invoking graphics.
- Graphics System - An interface that interacts between graphics library and Hardware
- Modifications to images are the result of user interaction.

Advantages of Interactive Graphics:-

→ Higher quality
→ More precise results or products
→ Greater productivity
→ Lower analysis and design cost
→ Significantly enhances our ability to understand data and perceive trends.

Unit-II

Q1) What is significance of homogeneous coordinate system in computer Graphics? Give 3D transformation matrices for rotation in homogeneous coordinate system.

Ans

Homogeneous coordinates are ubiquitous in computer graphics because they allow common vector operations such as translation, rotation, scaling and perspective projection to be represented as a matrix by which the vector is multiplied.

3D transformation matrices for rotation in homogeneous coordinate system :-

Rotation about x-axis :-
$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

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

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

Q) Magnify the triangle with vertices A(0,0), B(1,1), C(5,2) to twice it's size keeping C(5,2) fixed.

Ans:- Following steps are executed to magnify the triangle:-

Step1:-

First, we translate the ~~tri~~ triangle abc ~~toy~~ T_(-5, -2) so the point c(5,2) become (0,0)

Step 2:-

Make its size twice using the scale factor of 2.

Step 3:-

After following the above steps, we need to translate the triangle back ie translate the triangle by $T_{-}(5,2)$.

$\Rightarrow$ $T_{-}(a,b)$ moves all the points by a unit in x-direction and b unit in the y-direction.

so, translating the triangle by $T_{-}(-5,-2)$.

$a(0,0) \rightarrow a(0-5, 0-2) = a(-5,-2)$

$b(1,1) \rightarrow b(1-5, 1-2) = b(-4,-1)$

$c(5,2) \rightarrow c(5-5, 2-2) = c(0,0)$

Now, magnifying the size twice with scale factor of 2,

$a(-5,-2), \rightarrow a(-5*2, -2*2) = a(-10, 4)$

$b(-4,-1) \rightarrow b(-4*2, -1*2) = b(-8,-2)$

$c(0,0) \rightarrow c(0*2, 0*2) = c(0,0)$

Executing the last step, we get (Translate again):

$a(-10,-4) \rightarrow a(-10+5, -4+2) = a(-5,-2)$

$b(-8,-2) \rightarrow b(-8+5, -2+2) = b(-3,0)$

$c(0,0) \rightarrow c(0+5, 0+2) = c(5,2)$

The vertices of the magnified triangle to twice its size is a(-5,-2), b(-3,0), and c(5,2) keeping (5,2) fixed.

Q3) A Triangle is defined by A(2,2), B(4,2), C(4,4). Find the transform coordinate of the triangle after rotation about origin through 90°.

Sol^n: First we translate the traingle ABC to origin:

$A(2,2)$ after translation $\rightarrow A(2-2, 2-2) = (0,0)$

$B(4,2) \rightarrow (4-2, 2-2) = (2,0)$

$C(4,4) \rightarrow (4-2, 4-2) = (2,2)$

Now, rotate the triangle about the origin by $90°$
for every point we calculate -

$$[x \quad y] \begin{bmatrix} \cos 90° & \sin 90° \\ -\sin 90° & \cos 90° \end{bmatrix}$$

$$A(0,0) \rightarrow [0 \quad 0] \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} = [0 \quad 0]$$

$$B(2,0) \rightarrow [2, 0] \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} = [0 \quad 2]$$

$$C(2,2) \rightarrow [2, 2] \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} = [-2, 2]$$

Now transform the triangle again

$A \; [0+2 \quad 0+2] = A[2 \quad 2]$

$B \; [0+2, \quad 2+2] = B[2 \quad 4]$

$C \; [-2+2 \quad 2+2] = [0 \quad 4]$

The new coordinates of rotated triangle are $A(2,2)$, $B(2,4)$, $C(0,4)$

4Q.) Consider a square (0,2) (0,0), (2,2), (2,0)
i) Scale it by using $S_x = 2$ and $S_y = 3$

Solⁿ:- Given :- old corner coordinates of the square = A(0,2), B(0,0), C(2,2), D(2,0)
scaling factor along x-axis = 2, along y-axis = 2
New coordinates of corners af scaling →

$A_{New} = A \times (S_x, S_y) = (0, 2) \times (2, 3) = (0 \times 2, 2 \times 3) = (0, 6)$
$B_{New} = B \times (S_x, S_y) = (0 \times 2, 0 \times 3) = (0, 0)$
$C_{New} = (2 \times 2, 2 \times 3) = (4, 6)$
$D_{New} = (2 \times 2, 0 \times 3) = (4, 0)$

The New coordinates after scaling = A_{New} (0,6), B_{New} (0,0)
C_{New} (4,6), D_{New} (4,0)

ii) Translate it by $T_x = 3$, $T_y = 5$

Solⁿ:- New coordinates after translating →
$A_N = (0+3, 2+5) = (3, 7)$
$B_N = (x+T_x, y+T_y) = (0+3, 0+5) = (3, 5)$
$C_N = (2+3, 2+5) = (5, 7)$
$D_N = (2+3, 0+5) = (5, 5)$

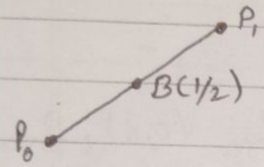
The New coordinates after translating A_N (3,7), B_N (3,5), C_N (5,7)
D_N (5,5)

Unit-III

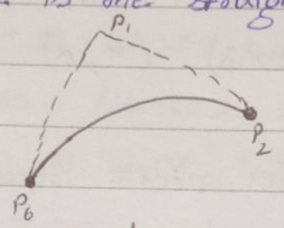
Date ____ Page 08

Q1) Explain how bezier curves are Represented parametrically. consider a Bezier curve having control points $P_1(20,0)$, $Q(0,20)$, $R(80,40)$, $S(40,0)$. compute the coordinates of the points. The curve for $t = 0.0, 0.2, 0.6, 1.0$

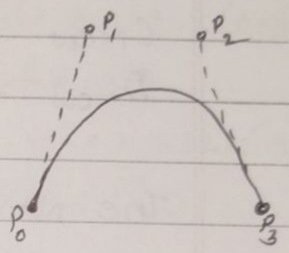
Ans Bezier curve is discovered by the french engineer pierre Bézier. These curves can be generated under the control of other points. Approximate tangents by using control points are used to generate curve. A quadratic Bezier curve is determined by three control points. A cubic Bezier curve is determined by four control points. The simplest Bézier curve is the straight line.



simple bezier curve



Quadratic Bezier curve



Cubic Bezier curve

Now,

we have - The given curve is defined by 4 control points $P(20,0)$, $Q(0,20)$, $R(80,40)$, $S(40,0)$

- So, the given curve is a cubic bezier curve

The parametric equation for a cubic bezier curve is-

$$P(t) = B_0(1-t)^3 + B_1 3t(1-t)^2 + B_2 3t^2(1-t) + B_3 t^3$$

$$\Rightarrow P(t) = P_1(1-t)^3 + Q\cdot 3t(1-t)^2 + R\,3t^2(1-t) + St^3$$

For $t = 0.0$

$$P(0) = [20\ 0](1-0)^3 + [0\ 20]\,3(0)(1-0)^2 + [80\ 40]\,3(0)^2(1-0) + [40\ 0](0)^3$$

$$= [20\ 0][01] + [0\ 20](0) + [80\ 40](0) + 0$$

$$= [20\ 0] + 0 + 0 + 0$$

$$P(0) = [20\ 0]$$

For $t=0.2$

$$P(t) = P_1(1-t)^3 + Q \cdot 3t(1-t)^2 + R\,3t^2(1-t) + St^3$$
$$= P_1(1-0.2)^3 + 3\times(.2)\,Q\,(1-0.2)^2 + 3(0.2)^2 R(1-0.2) + S(0.2)^3$$
$$= P_1 \times 0.512 + Q \times 0.384 + R \times 0.096 + S \times 0.008$$
$$= [20 \quad 0] \times 0.512 + [0 \quad 20] \times 0.384 + [80 \quad 40] \times 0.096 + [40 \quad 0] \times 0.008$$
$$= [10.24 \quad 0] + [0 \quad 7.68] + [7.68 \quad 3.84] + [0.32 \quad 0]$$
$$P(0.2) = [18.24 \quad 11.52]$$

For $t=0.6$

$$P(0.6) = P_1(1-0.6)^3 + Q \cdot 3t(1-0.6)^2 + R\,3(0.6)^2(1-0.6) + S(0.6)^3$$
$$= P_1 \times 0.064 + Q \times 0.288 + R \times 0.432 + S \times .216$$
$$= [20 \quad 0] \times 0.064 + [0 \quad 20] \times 0.288 + [80 \quad 40] \times 0.432 + [40 \quad 0] \times 0.008$$
$$= [1.28 \quad 0] + [0 \quad 5.76] + [34.56 \quad 17.28] + [0.32 \quad 0]$$
$$P(0.6) = [36.16 \quad 23.04]$$

For $t=1.0$

$$P(1) = P_1(1-1)^3 + Q \cdot 3 \cdot (1)(1-1)^2 + R\,3(1)^2(1-1) + S(1)^3$$
$$= P_1 \times 0 + 3Q \times 0 + 3R \times (0) + S \times 1$$
$$= 0 + 0 + 0 + [40 \quad 0]$$
$$P(1) = [40 \quad 0]$$

Q2) What is CSG. Discus various user interfaces for solid modeling

Ans: Constructive solid geometry allows a modeler to create a complex surface or object by using Boolean operators to combine simpler objects, potentially generating visually complex objects by combining a few primitive ones.

Solid Modeling (or Modelling) is a consistent set of principles for mathematical and computer modeling of 3D solids. solid modeling is distinguished from related areas of geometric modeling and computer graphics, such as 3D

Modeling, by its emphasis on physical fidelity. Together, the principles of geometric and solid modeling form the foundation of 3D-computer-aided design and in general support the creation, exchange, visualization, animation, interrogation, and annotation of digital models of physical objects.

The use of solid modeling techniques allows for the automation of several difficult engineering calculations that are carried out as a part of the design process. Simulation, planning, and verification of processes such as machining and assembly were one of the main catalysts for the development of solid modeling. More recently, the range of supported manufacturing applications has been greatly expanded to include sheet metal manufacturing, injection molding, welding, pipe routing, etc.

Q3 a) Define Parametric Bicubic surface.

Ans A bicubic Bézier surface is a parametric surface (u,v = [0,1] (0,1)) defined by its sixteen control points which lie in a four-by-four grid, Pij. The common form for representing this surface is:

$$Q(u,v) = \sum_{i=0}^{3}\sum_{j=0}^{3} P_{ij}\, B_i(u)\, B_j(v)$$

The functions $B_i(u)$ and $B_j(v)$ are the same Bernstein polynomials which were shown for the Bézier curve.

b) Discuss Hermite surface in details.

Ans A Hermite curve is a spline where every piece is a third degree polynomial defined in Hermite form: that is, by its values and initial derivatives at the end points of the equivalent domain interval. The Hermite formula is used to every interval (x_k, x_{k+1}) individually. The resulting spline become continuous and will have first derivative.

Q4) a) Explain How solids are represented Using Boundary Representation (B-rep) Technique and constructive solid geometry (CSG) Technique.

Ans In solid modeling and computer-aided design, boundary representation (B-rep) is a method for representing a 3D shape by defining the limits of its volume. A solid is represented as a collection of connected surface elements, which define the boundary between interior and exterior points.

CSG objects can be represented by binary trees, where leaves represent primitives, and nodes represent operations. It essentially consists of using primitive solid objects and doing boolean operation with them, such as fusion, subtraction and intersection, in order to create a final shape.

b) Describe polygon Meshes.

Ans A polygon mesh is a collection of edges, faces and connecting points that is used to provide a polygon model for 3-D modeling and computer animation. Its geometric makeup can be stored in order to facilitate various kinds of simulation of three-dimensional renderings.

Unit - IV

Q 1) "Hidden surface should be removed" why? Discuss painter's algorithm for hidden surface removal.

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

The painter's algorithm (also depth-sort algorithm and priority fill) is an algorithm for visible surface determination in 3D computer graphics that works on a polygon-by-polygon basis rather than a pixel-by pixel, row by row, or area by area basis of other Hidden surface Removal algorithms.

Q 2) Define projection? Differentiate between parallel and perspective projection with suitable example.

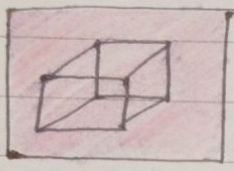
Ans Projection is the process of converting a 3D object into a 2D object. It is also defined as mapping or transformation of the object in projection plane or view plane.

Difference between parallel projection and perspective projection are as follows.

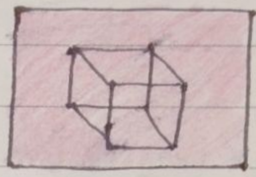
Parallel projection	Perspective Projection
Parallel projection represents the object in a different way like telescope.	Perspective projection represents the object in three dimensional way.
It can give the accurate view of object.	It cannot give the accurate view of object.

The lines of parallel projection are parallel	The lines of perspective projection are not parallel.
It does not form realistic view of object.	It forms a realistic view of object

Example of parallel porjection :-
projection of a cube.

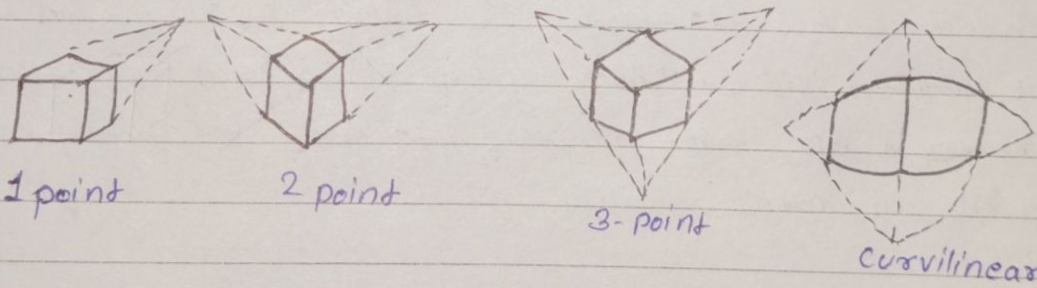


In this orthographic projection, the projection lines are perpendicular to the image plane



In an oblique projection lines are at a skew angle to the image plane

Example of perspective projection:-



Q3.) a) Define principal vanishing point. Discuss types of perspective projections.

Ans The vanishing point theorem is the principal theorem in the science of perspective. It says that the image in a picture plane π of a line L in space, not parallel to the picture, is determined by its intersection with π and its vanishing point

There are 3 types of perspective projects i.e:-

- one point perspective projection is simple to draw

- Two point perspective projection gives better impression of depth.
- Three point perspective projection is most difficult to draw

b) How parallel projections are different from perspective projections?

Ans Parallel projection represents the object in a different way like telescope. while perspective projection represents the object in three dimensional way, objects that are far away appear smaller, and objects that are near appear bigger.

Q4.) Explain the Depth Sorting Algorithm for Hidden Surface Removal.

Ans The hidden surface removal is the procedure used to find which surfaces are not visible from a certain view. A hidden surface removal algorithm is a solution to the visibility issue, which was one of the first key issues in the field of 3D graphics. The procedure of hidden surface identification is called as hiding, and such an algorithm is called a 'hider'. Hidden surface identification is essential to render a 3D image properly, so that one cannot see through walls in virtual reality.