1. What do you mean by Computer Graphics?
   The Computer Graphics is one of the most effective and commonly used way to communicate the processed information to the user. It displays the information in the form of graphic objects such as pictures, charts, graphs and diagrams instead of simple text. Thus we can say that computer graphics makes it possible to express data in pictorial form. The picture or graphics object may be an engineering drawing, business graphs, architectural structures, a single frame from an animated movie, or a machine parts illustrated for a service manual.
   In computer graphics, pictures or graphics objects are presented as a collection of discrete picture elements called pixels. The pixel is the smallest addressable screen element.

2. What are the different between raster and vector graphics

The main difference between vector and raster graphics is that raster graphics are composed of pixels, while vector graphics are composed of paths. A raster graphic, such as a gif or jpeg, is an array of pixels of various colors, which together form an image.

Raster Graphics	Vector Graphics
They are composed of pixels.	They are composed of paths.
In Raster Graphics, refresh process is independent of the complexity of the image.	Vector displays flicker when the number of primitives in the image become too large.
Graphic primitives are specified in terms of end points and must be scan converted into corresponding pixels.	Scan conversion is not required.
Raster graphics can draw mathematical curves, polygons and boundaries of curved primitives only by pixel approximation.	Vector graphics draw continuous and smooth lines.
Raster graphics cost less.	Vector graphics cost more as compared to raster graphics.
They occupy more space which depends on image quality.	They occupy less space.
File extensions: .BMP, .TIF, .GIF, .JPG	File Extensions: .SVG, .EPS, .PDF, .AI, .DXF

3. Define Frame buffer, Persistence, Resolution and Aspect Ratio

Frame Buffer - Picture definition is stored in a memory area called the refresh buffer or frame buffer. This memory area holds the set of intensity values for all the screen points.

Persistence - Persistence is the one of the major property of phosphorous used in CRT’s. It means how long they continue to emit light after the electron beam is removed.

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

Aspect Ratio - Aspect ratio is a number which gives the ratio of vertical points to horizontal points necessary to produce equal length lines in both directions on the screen. An aspect ratio of ¾ means that a vertical line plotted with three points has same length as a horizontal line plotted with 4 points.

4. Differentiate between DDA algorithm and Bresenham’s algorithm.

S.NO	DDA LINE ALGORITHM	BRESENHAM LINE ALGORITHM
1.	DDA stands for Digital Differential Analyzer.	While it has no full form.
2.	DDA algorithm is less efficient than Bresenham line algorithm.	While it is more efficient than DDA algorithm.

3.	The calculation speed of DDA algorithm is less than Bresenham line algorithm.	While the calculation speed of Bresenham line algorithm is faster than DDA algorithm.
4.	DDA algorithm is costlier than Bresenham line algorithm.	While Bresenham line algorithm is cheaper than DDA algorithm.
5.	DDA algorithm has less precision or accuracy.	While it has more precision or accuracy.
6.	In DDA algorithm, the complexity of calculation is more complex.	While in this, the complexity of calculation is simple.
7.	In DDA algorithm, optimization is not provided.	While in this, optimization is provided.

5. Define Random Scan and Raster Scan Display systems.

S.NO	RANDOM SCAN	RASTER SCAN

1.	The resolution of random scan is higher than raster scan.	While the resolution of raster scan is lesser or lower than random scan.
2.	It is costlier than raster scan.	While the cost of raster scan is lesser than random scan.
3.	In random scan, any alteration is easy in comparison of raster scan.	While in raster scan, any alteration is not so easy .
4.	In random scan, interweaving is not used.	While in raster scan, interweaving is used.
5.	In random scan, mathematical function is used for image or picture rendering.	While in which, for image or picture rendering, raster scan uses pixels.
6.	It is suitable for applications requiring polygon drawings.	It is suitable for creating realistic scenes.

6. Define Translation, Rotation, Scaling, Shearing and Reflection

Translation

A translation moves an object to a different position on the screen. You can translate a point in 2D by adding translation coordinate (t_x, t_y) to the original coordinate

X,Y

X,Y to get the new coordinate

X

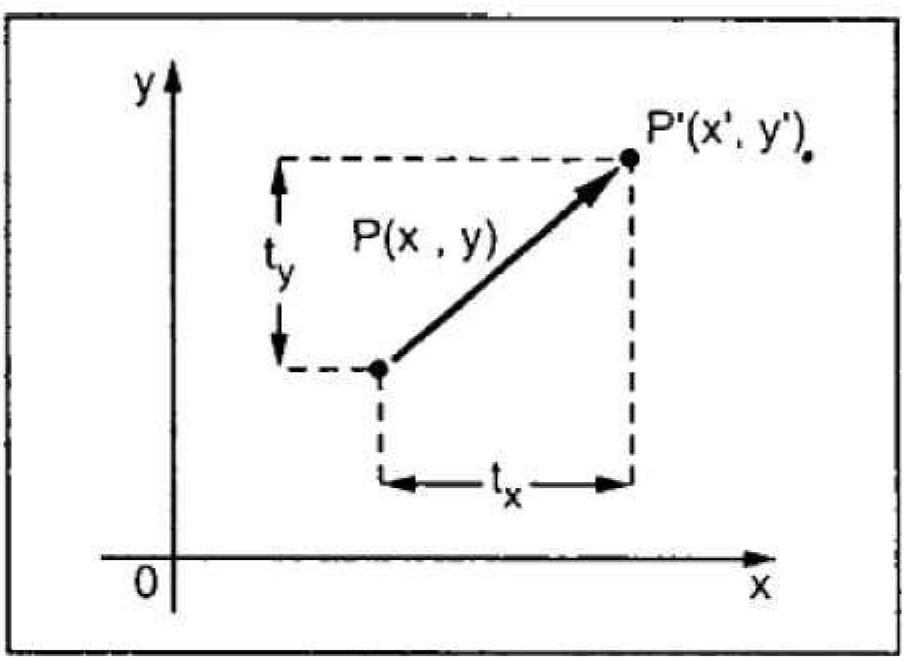
′

,

Y

′

X′,Y′.



From the above figure, you can write that −

$$X' = X + t_x$$

$$Y' = Y + t_y$$

The pair (t_x, t_y) is called the translation vector or shift vector. The above equations can also be represented using the column vectors.

$$P = \frac{[X]}{[Y]} \qquad p' = \frac{[X']}{[Y']} \qquad T = \frac{[t_x]}{[t_y]}$$

We can write it as −

$$P' = P + T$$

In rotation, we rotate the object at particular angle θ

theta

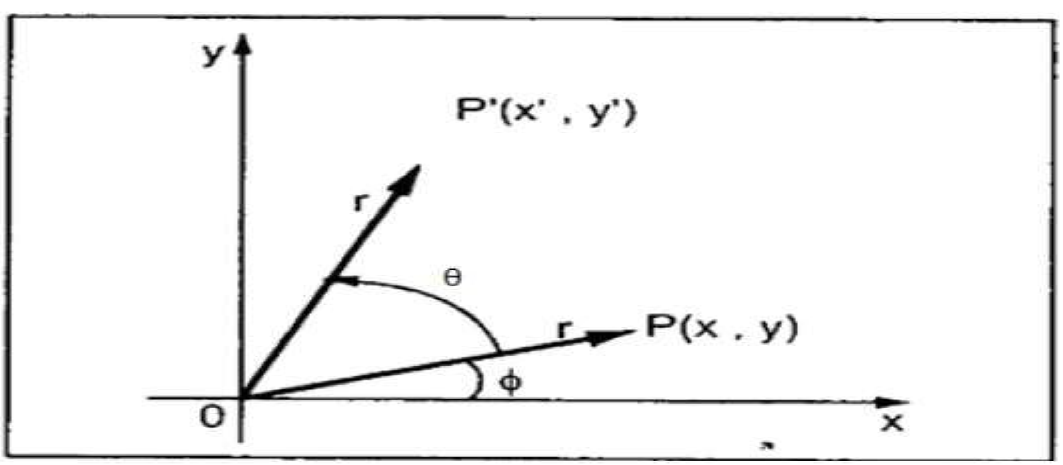
theta from its origin. From the following figure, we can see that the point P

X,Y

X,Y is located at angle φ from the horizontal X coordinate with distance r from the origin.

Let us suppose you want to rotate it at the angle θ. After rotating it to a new location, you will get a new point P'

X′,Y′.



Using standard trigonometric the original coordinate of point P X, Y can be represented as −

$$X = r\,cos\,\phi ......(1)$$

$$Y = r\,sin\,\phi ......(2)$$

Same way we can represent the point P' X', Y' as −

$$x' = r\,cos\;(\phi\,+\,\theta) = r\,cos\,\phi\,cos\,\theta\;-\;r\,sin\,\phi\,sin\,\theta ....(3)$$

$$y' = r\,sin\;(\phi\,+\,\theta) = r\,cos\,\phi\,sin\,\theta\;+\;r\,sin\,\phi\,cos\,\theta ....(4)$$

Substituting equation 1 & 2 in 3 & 4 respectively, we will get

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

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

Representing the above equation in matrix form,

$$[X'Y'] = [XY]\begin{bmatrix} cos\theta & sin\theta \\ -sin\theta & cos\theta \end{bmatrix} OR$$

P' = P . R

Where R is the rotation matrix

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

The rotation angle can be positive and negative.

For positive rotation angle, we can use the above rotation matrix. However, for negative angle rotation, the matrix will change as shown below −

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

$$= \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix} (\because cos(-\theta) = cos\theta \; and \; sin(-\theta) = -sin\theta)$$

Scaling

To change the size of an object, scaling transformation is used. In the scaling process, you either expand or compress the dimensions of the object. Scaling can be achieved by multiplying the original coordinates of the object with the scaling factor to get the desired result.

Let us assume that the original coordinates are X, Y , the scaling factors are (S_X, S_Y), and the produced coordinates are X', Y' . This can be mathematically represented as shown below −

$X' = X . S_X$ and $Y' = Y . S_Y$

The scaling factor S_X, S_Y scales the object in X and Y direction respectively. The above equations can also be represented in matrix form as below −

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} X \\ Y \end{pmatrix} \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix}$$

OR

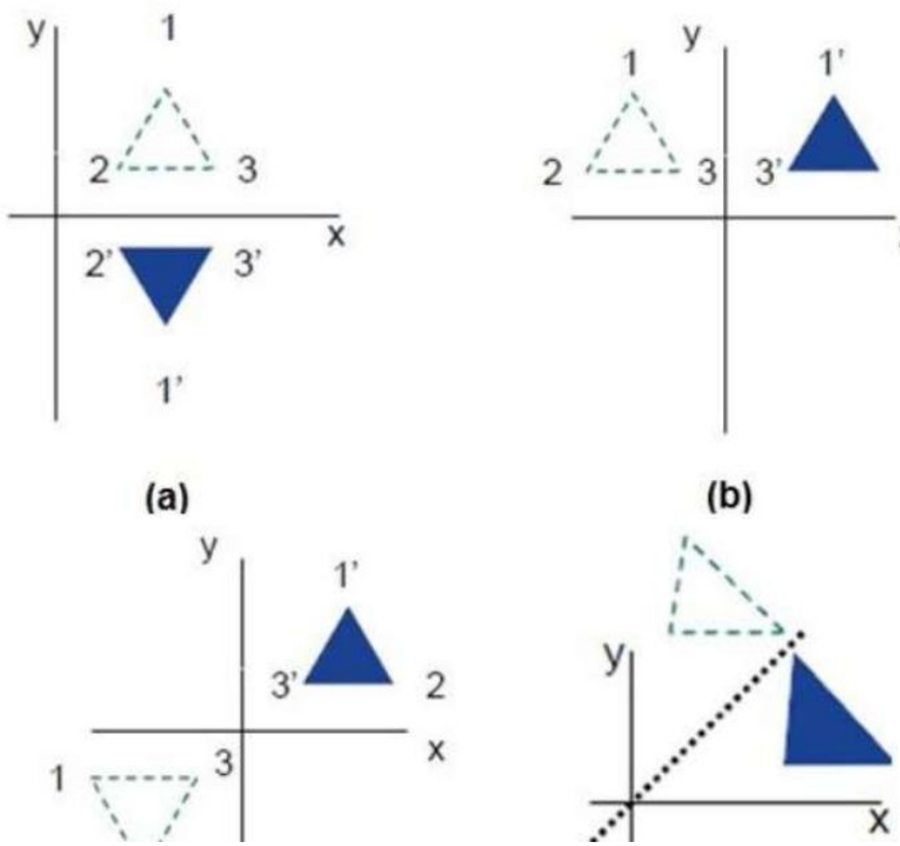
P’ = P . S

Where S is the scaling matrix. The scaling process is shown in the following figure.

Reflection

Reflection is the mirror image of original object. In other words, we can say that it is a rotation operation with 180°. In reflection transformation, the size of the object does not change.

The following figures show reflections with respect to X and Y axes, and about the origin respectively.

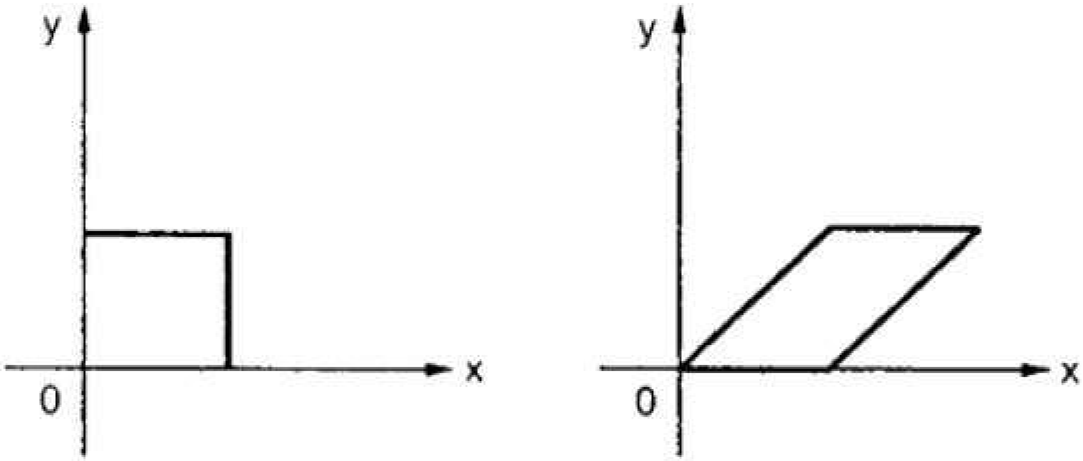


Shear

A transformation that slants the shape of an object is called the shear transformation. There are two shear transformations X-Shear and Y-Shear. One shifts X coordinates values and other shifts Y coordinate values. However; in both the cases only one coordinate changes its coordinates and other preserves its values. Shearing is also termed as Skewing.

X-Shear

The X-Shear preserves the Y coordinate and changes are made to X coordinates, which causes the vertical lines to tilt right or left as shown in below figure.



(a) Original object (b) Object after x shear

The transformation matrix for X-Shear can be represented as −

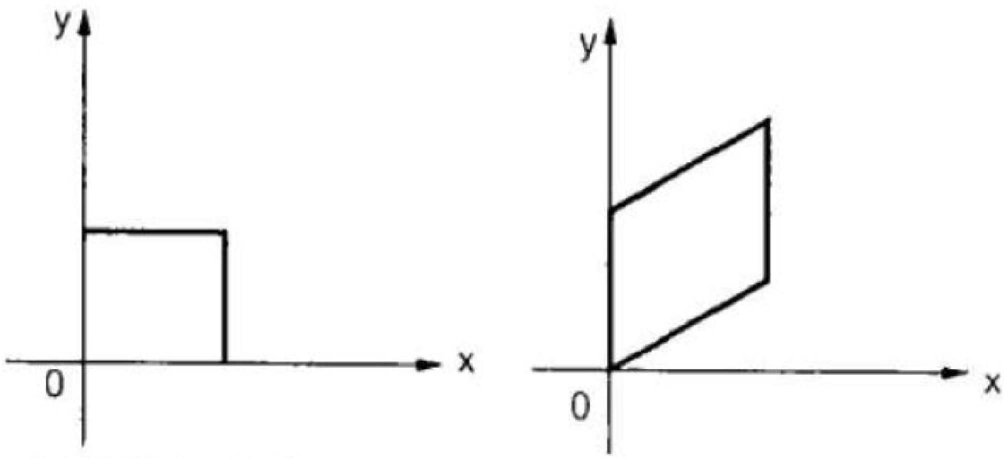
$$X_{sh} = \begin{bmatrix} 1 & shx & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$Y' = Y + Sh_y \, . \, X$$

$$X' = X$$

Y-Shear

The Y-Shear preserves the X coordinates and changes the Y coordinates which causes horizontal lines to transform into lines which slopes up or down as shown in the following figure.



(a) Original object (b) Object after y shear

The Y-Shear can be represented in matrix from as −

$$Y_{sh} \begin{bmatrix} 1 & 0 & 0 \\ shy & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$X' = X + Sh_x \cdot Y$$

$$Y' = Y$$

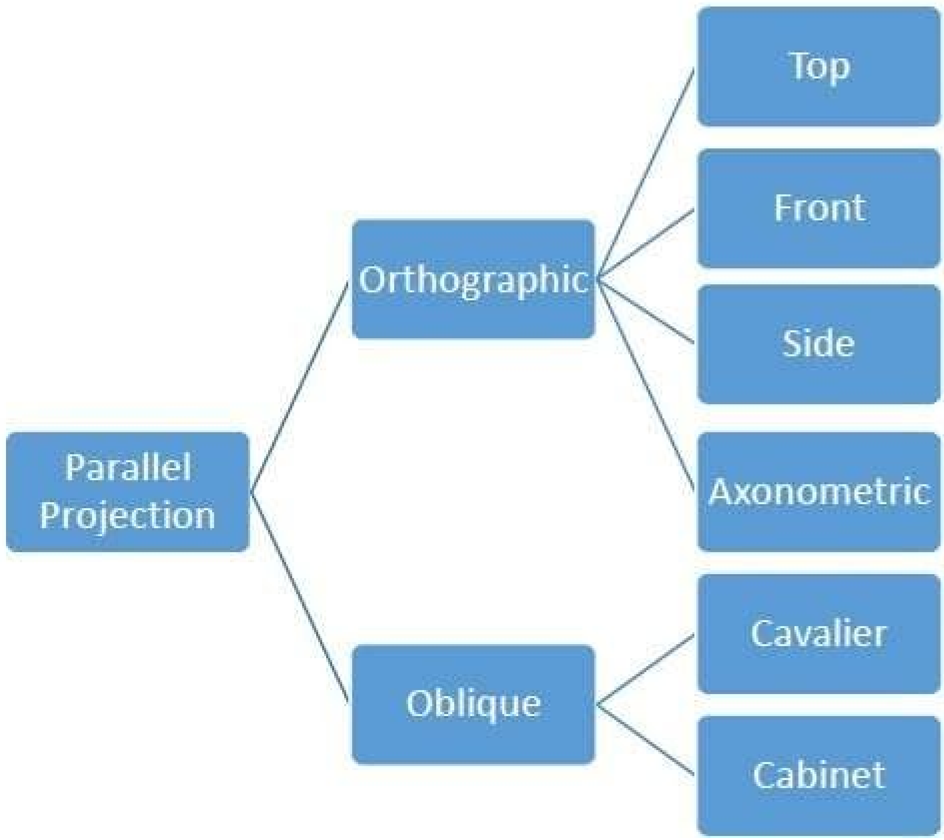
7. Differentiate between parallel and perspective projection.

Parallel Projection

Parallel projection discards z-coordinate and parallel lines from each vertex on the object are extended until they intersect the view plane. In parallel projection, we specify a direction of projection instead of center of projection.

In parallel projection, the distance from the center of projection to project plane is infinite. In this type of projection, we connect the projected vertices by line segments which correspond to connections on the original object.

Parallel projections are less realistic, but they are good for exact measurements. In this type of projections, parallel lines remain parallel and angles are not preserved. Various types of parallel projections are shown in the following hierarchy.

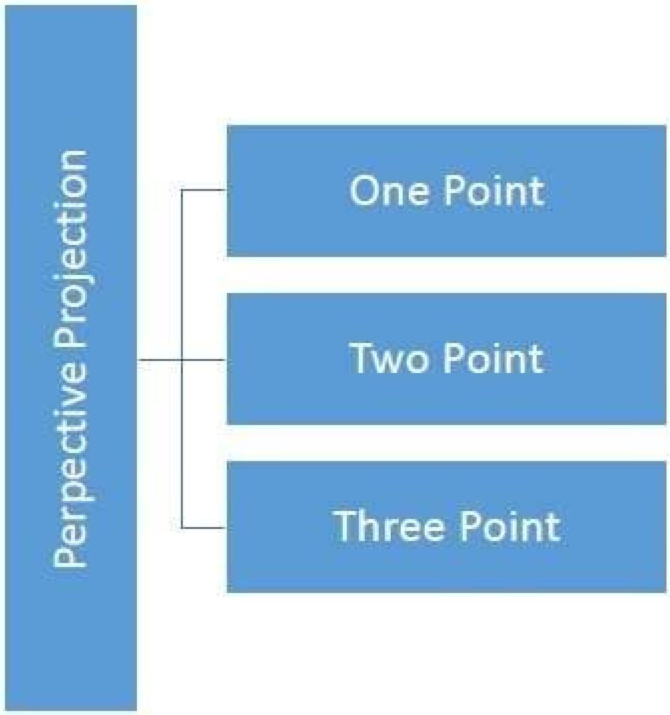


Perspective Projection

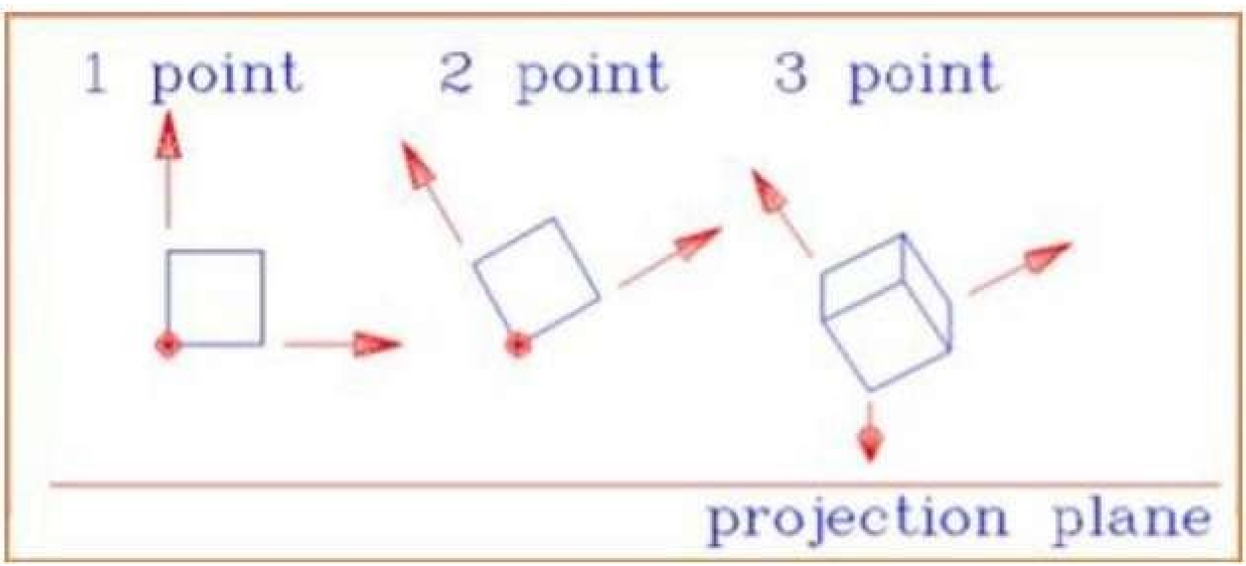
In perspective projection, the distance from the center of projection to project plane is finite and the size of the object varies inversely with distance which looks more realistic.

The distance and angles are not preserved and parallel lines do not remain parallel. Instead, they all converge at a single point called center of projection or projection reference point. There are 3 types of perspective projections which are shown in the following chart.

- 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.



The following figure shows all the three types of perspective projection −



Study this link too -
https://www.tutorialspoint.com/computer_graphics/3d_computer_graphics.htm

8. What is the need of homogeneous coordinates?

One of the many purposes of using homogeneous coordinates is to capture the concept of infinity. The coordinate system we use to denote the location of an object is called Euclidean coordinate system. If we are considering a 3-dimensional space, it's just a nice triplet of numbers! In this system, infinity is something that does not exist. I have covered it in detail here. Mathematicians have discovered that many geometric concepts and computations can be greatly simplified if the concept of infinity is used. But the constraint is that we cannot treat infinity like a regular number. If we don't use homogeneous coordinates, it would be difficult to design certain classes of very useful curves and surfaces. These curves and surfaces are very crucial in developing algorithms in computer vision, graphics, CAD, etc.

Projective geometry relies heavily on homogeneous coordinates as well

9. Why do we need viewing transformation?

1. The viewing transformation converts objects from their 3-dimensional camera-space coordinates into the appropriate 2-dimensional raster-space coordinates.
2. The camera coordinate system is a coordinate system with the camera at the origin, looking out over the positive z axis.
3. It is, essentially, the scene from the camera's point of view. The raster coordinate system is the space of the pixels on the monitor.
4. Connecting these two coordinate systems there is a special coordinate system known as the screen coordinate system.
5. The screen coordinate system is, conceptually, the same as the film plane of a camera.
6. It is usually best to consider both the screen coordinate system and the raster coordinate system to be two-dimensional, even though we know that RenderMan can output depth information.
7. The RenderMan Interface Specification has a rather complex viewing transformation. The interface has many calls which each set-up a small piece of the transformation.
8. Each of these values has a “reasonable” default, which is to say that if you don't set it, it will default to something which is probably appropriate, given the values that you have already set.
9. The viewing transformation has lots of controls, but typically they are not all used together. Rather, a couple important controls are set and the rest are let to default to their “logical” values.

10. The viewing transformation can be broken down into two pieces, the camera-to-screen projection and the screen-to-raster projection.
    - The camera-to-screen projection flattens the 3-D world onto the 2-D screen.
    - The screen-to-raster projection maps every point on the screen onto some output pixel.

10. What are the steps involved in 3D transformation?

Modeling Transformation

Projection Transformation

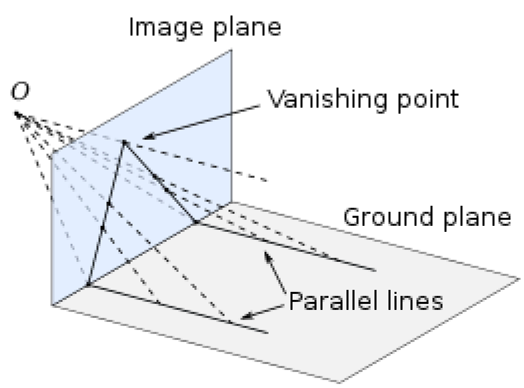
Viewing Transformation

Workstation Transformation

11. What do you mean by Vanishing point and projection reference points?

Vanishing points

A **vanishing point** is a point on the image plane of a perspective drawing where the two-dimensional perspective projections (or drawings) of mutually parallel lines in three-dimensional space appear to converge. When the set of parallel lines is perpendicular to a picture plane, the construction is known as one-point perspective, and their vanishing point corresponds to the oculus, or "eye point", from which the image should be viewed for correct perspective geometry.



Projection Reference points

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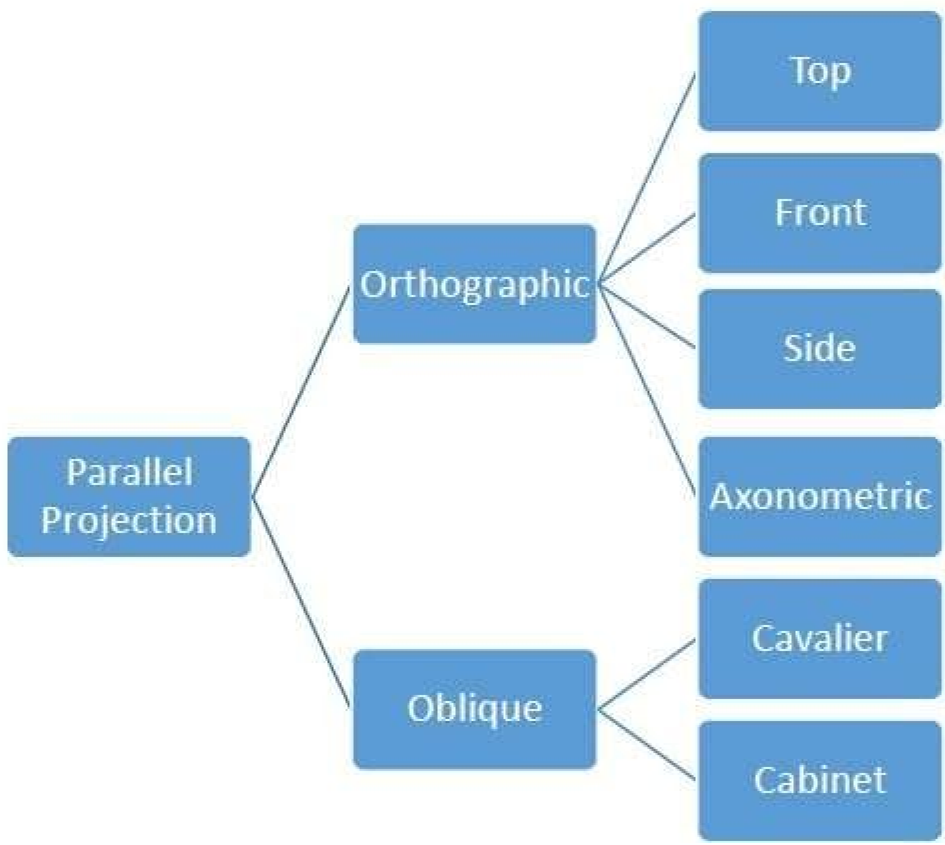
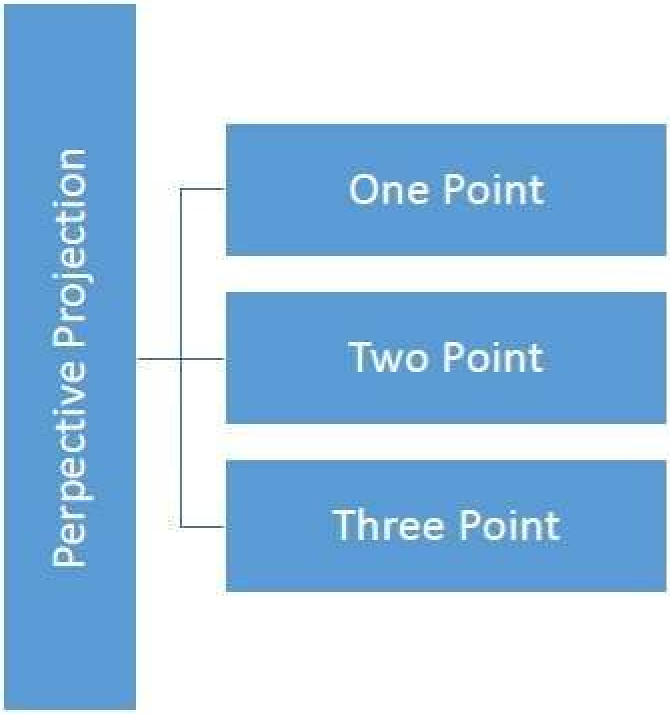
12. List various types of parallel and perspective projections.





Perpective Projection
One Point
Two Point
Three Point