Shri Vishwakarma Skill University

Course - B.Voc Tool & Die Manufacturing

Subject - CAD

Unit 2

Transformation

Transformation: Output primitives (points, lines, curves, etc.), 2D & 3D transformation (Translation, Scaling & rotation). Projections: orthographic & Isometric.

Output primitives: Output Primitives are the basic entities that are used to draw an object. These are basic structures that are used such that to give the shape of an object. The Primitives are the simple geometric functions that are used to generate various Computer Graphics required by the User. However different Graphic packages offers different output primitives like a rectangle, conic section, circle, spline curve or may be a surface. Once it is specified what picture is to be displayed, various locations are converted into integer pixel positions within the frame buffer and various functions are used to generate the picture on the two dimensional coordinate system of output display.

Point Function

A point function is the most basic Output primitive in the graphic package. A point function contains location using x and y coordinate and the user may also pass other attributes such as its intensity and color.

Line Function

A line function is used to generate a straight line between any two end points. Usually a line function is provided with the location of two pixel points called the starting point and the end point

2D Transformation: Transformation means changing some graphics into something else by applying rules. When a transformation takes place on a 2D plane, it is called 2D transformation. For a given 2D object, transformation is to change the objects.

1. Position (Translation)

2. Size (Scaling)

3. Orientation (Rotation)

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, t_x and t_y , to the original coordinate position *(x,y)* to move the point to a new position *(x',y')*

The translation distance pair *(tx, ty)* is called translation vector or shift vector

$$x' = x + T_x \qquad y' = y + T_y$$

$$P' = P + T$$

Matrix representation of translation

$$\begin{bmatrix} x' & y' \end{bmatrix} = \begin{bmatrix} x & y \end{bmatrix} + \begin{bmatrix} T_x & T_y \end{bmatrix}$$

Scaling:

Scaling is a kind of transformation in which the size of an object is changed. Remember the change is size does no mean any change in shape. This kind of transformation can be carried out for polygons by multiplying each coordinate of the polygon by the scaling factor. S_x and S_y which in turn produces new coordinate of *(x,y)* as *(x',y')*. The equation would look like

$$\begin{bmatrix} x' & y' \end{bmatrix} = \begin{bmatrix} x & y \end{bmatrix} \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix}$$

Or

P' = S.P

here *S* represents the scaling matrix.
<u>NOTE</u>: If the values of scaling factor are greater than 1 then the object is enlarged and if it is less that 1 it reduces the size of the object. Keeping value as 1 does not changes the object

Uniform Scaling: To achieve uniform scaling the values of scaling factor must be kept equal.

Differential Scaling: Unequal or Differential scaling is produce in cases when values for scaling factor are not equal.

Rotation:

In rotation, we rotate the object at particular angle θ (theta) from its origin.
A two-dimensional rotation is applied to an object by repositioning it along a circular path in the *x-y* plane. When we generate a rotation we get a rotation angle *(ϑ)* and the position about which the object is rotated (x_r, y_r) this is known as **rotation point** or **pivot point**.

we can express the transformation by the following equations

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

on expanding and equating we get

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

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

If Rotation matrix, R is used for defining the rotation.

Where the rotation matrix R is

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

Hence it is

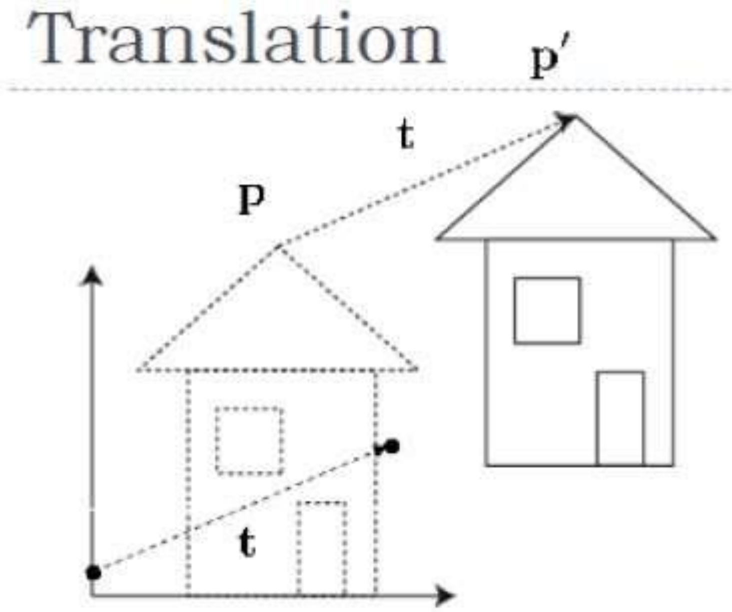
$$\begin{bmatrix} x' & y' \end{bmatrix} = \begin{bmatrix} x & y \end{bmatrix} \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix}$$

P' = P.R

3D transformation: Methods for object modelling transformation in three dimensions are extended from two dimensional methods by including consideration for the z coordinate.

3D TRANSLATION:

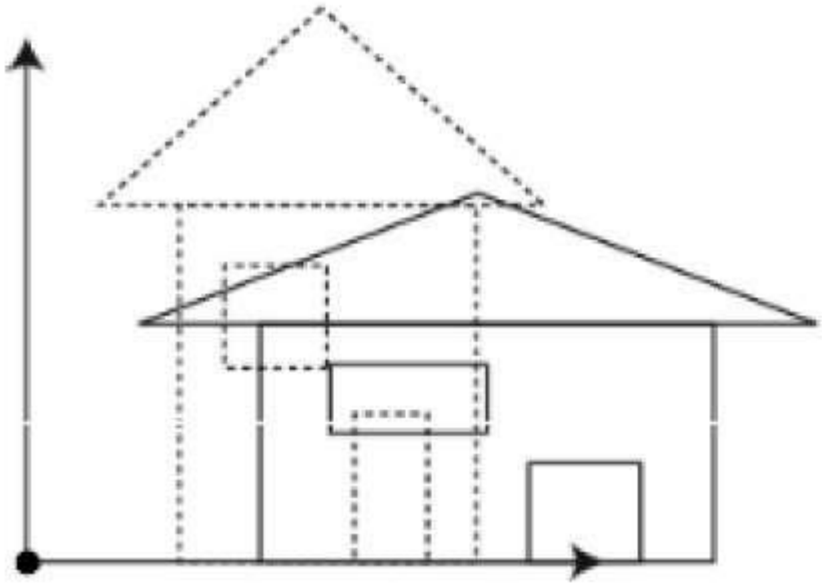
In 3D translation, we transfer the Z coordinate along with the X and Y coordinates. The process for translation in 3D is similar to 2D translation. A translation moves an object into a different position on the screen. The following figure shows the effect of translation –



A point can be translated in 3D by adding translation coordinate (t_x, t_y, t_z) to the original coordinate (X, Y, Z) to get the new coordinate (x′,y′,z′).

SCALING:-

You can change the size of an object using scaling transformation. 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. The following figure shows the effect of 3D scaling −

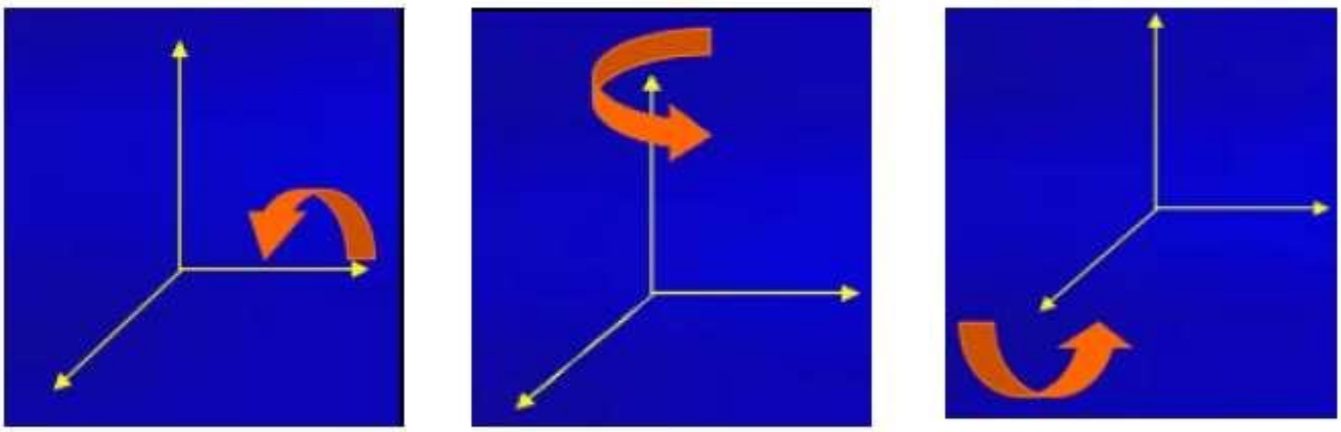


In 3D scaling operation, three coordinates are used. Let us assume that the original coordinates are (X, Y, Z), scaling factors are (S_X, S_Y, S_z) respectively, and the produced coordinates are (X′, Y′, Z′). This can be mathematically represented as shown below −

$$S = P \cdot S$$

ROTATION:

3D rotation is not same as 2D rotation. In 3D rotation, we have to specify the angle of rotation along with the axis of rotation. We can perform 3D rotation about X, Y, and Z axes



Rotation about x-axis   Rotation about y-axis   Rotation about z-axis

http://ae.sharif.edu/~aerocad/3D%20Transformation.pdf

PROJECTION:

ORTHOGRAPHIC Projection:

A system of making engineering drawings showing several different views of an object at right angles to each other on a single drawing

In orthographic projection the direction of projection is normal to the projection of the plane.

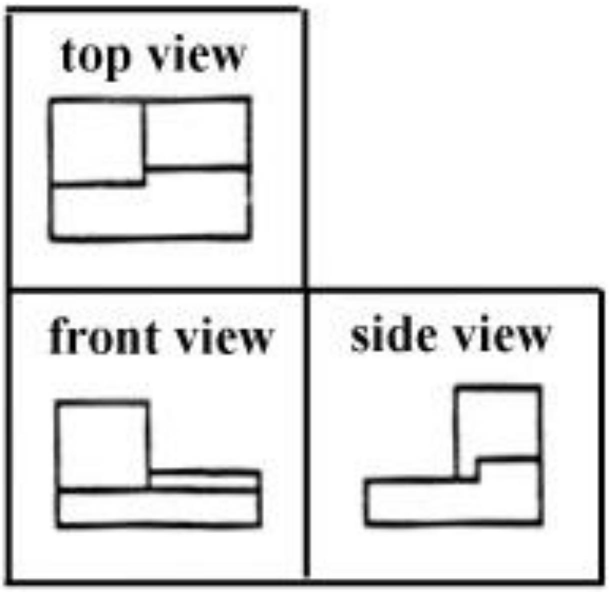
Orthographic projections that show more than one side of an object are called **axonometric orthographic projections**.

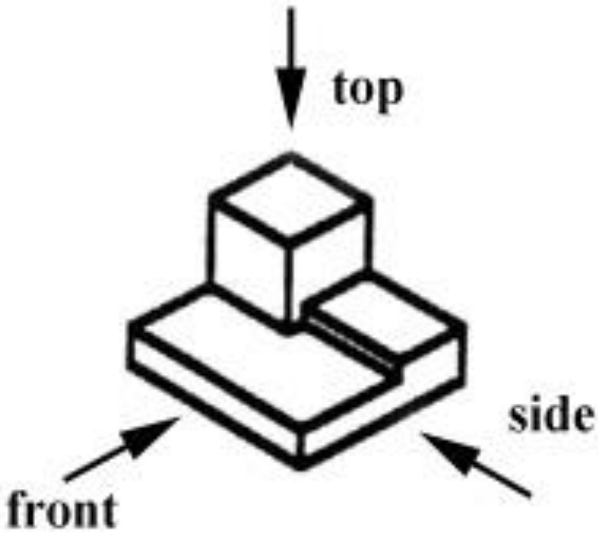
There are three types of orthographic projections − Front Projection, Top Projection & Side Projection

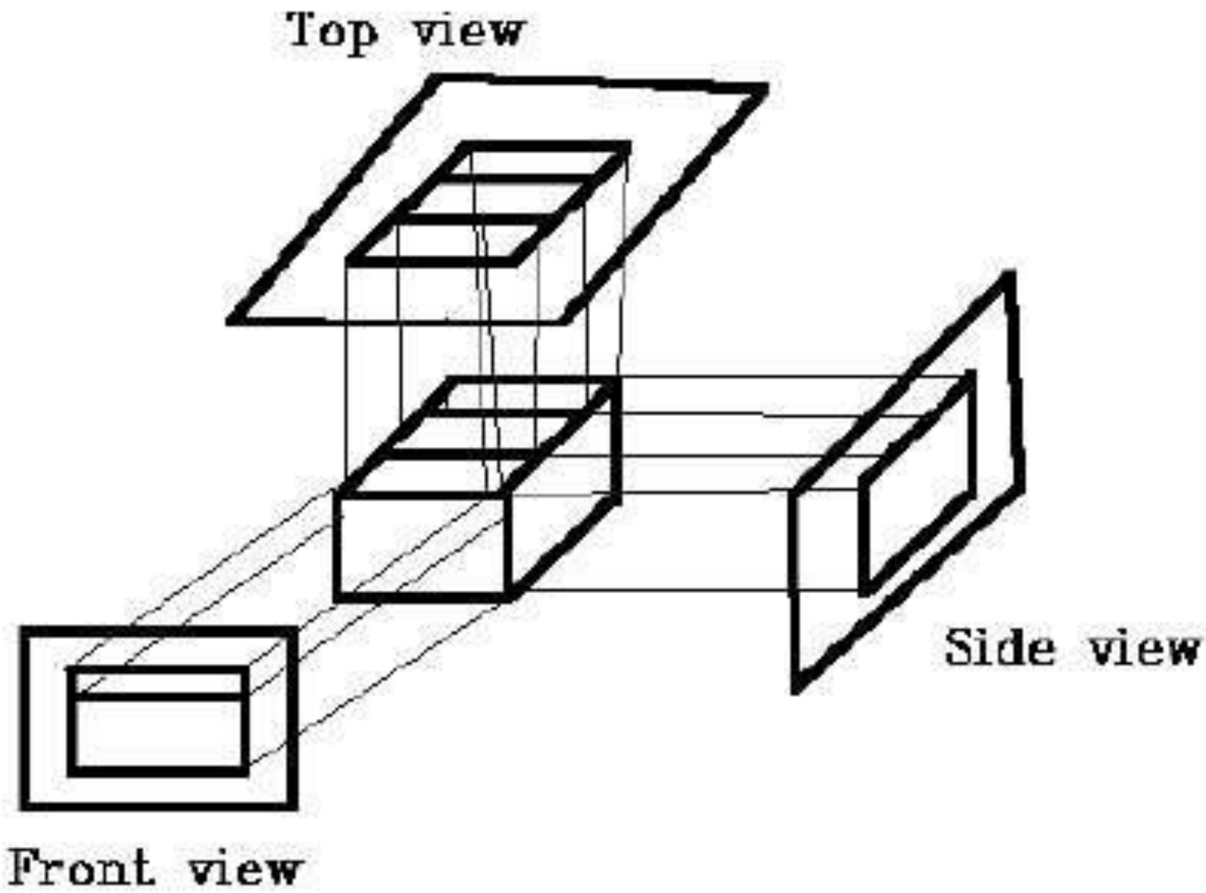
1 FRONT SIDE

2 TOP

3 SIDE







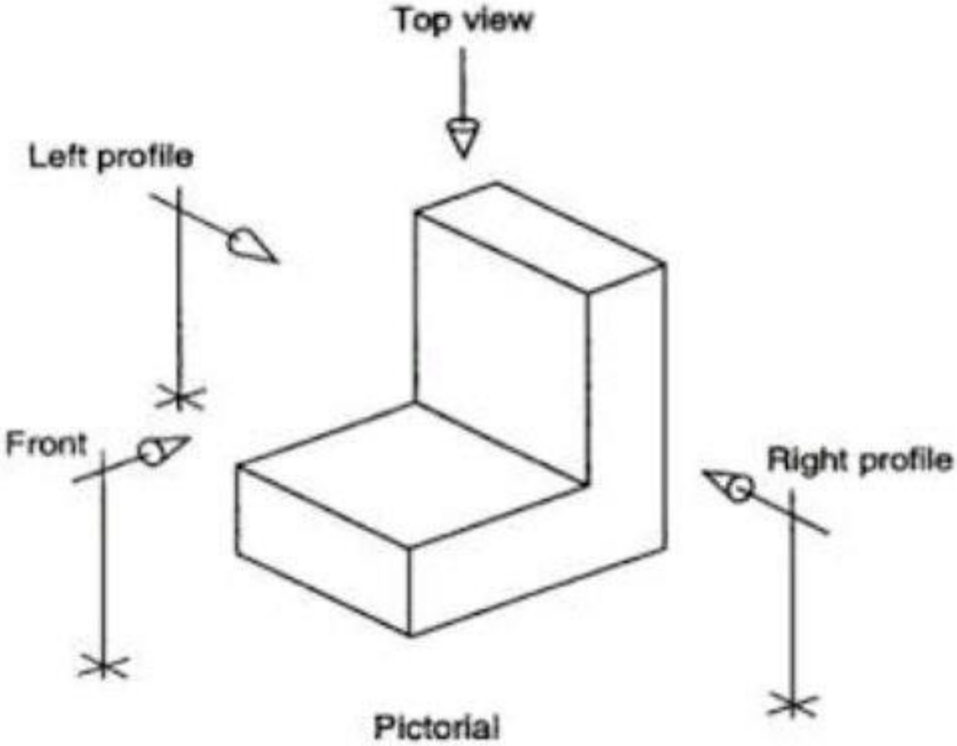
ISOMETRIC PROJECTION:

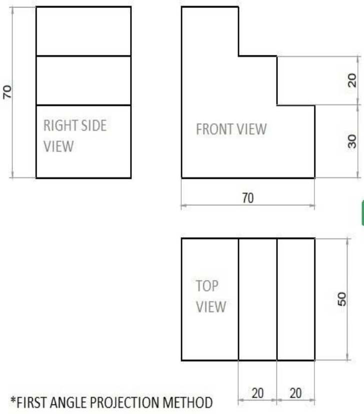
Isometric projection is a method for visually representing three-dimensional objects in two dimensions in technical and engineering drawings. It is an axonometric **projection** in which the three coordinate axes appear equally foreshortened and the angle between any two of them is 120 degrees

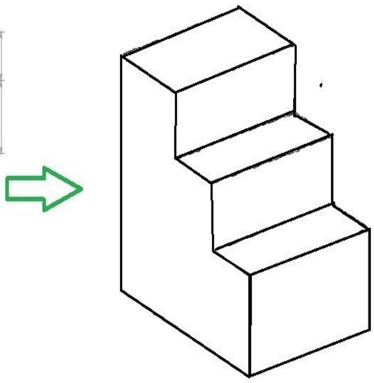
The most common axonometric projection is an **isometric projection** where the projection plane intersects each coordinate axis in the model coordinate system at an equal distance.

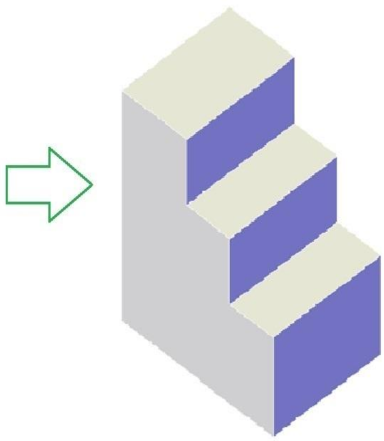
Isometric projection of an object is how the object looks to naked eye when seen from a distance. When seen from a distance the object doesn't look as it actually is, it looks smaller and so is the isometric projection of the object.

Isometric projection









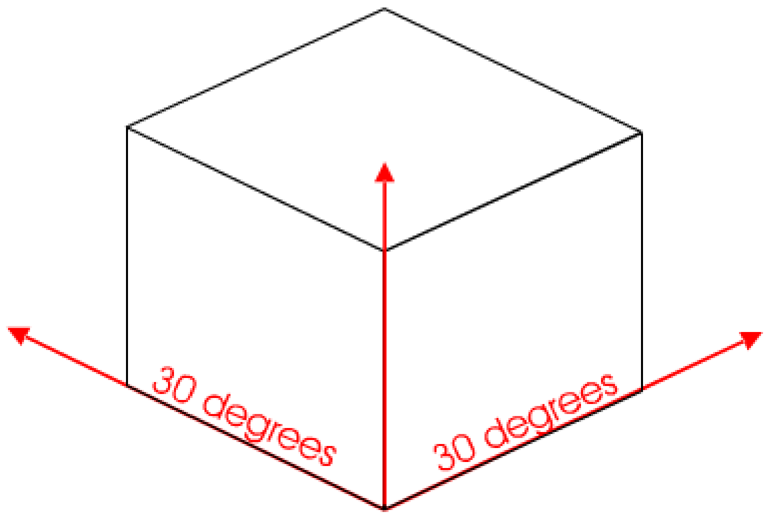
Orthographic Views

Multiple 2D Views

Isometric View

One 3D View

Realistic View



Difference between two

Projections: orthographic vs Isometric

I have summed up these two methods of drawing which are as follows

1. Orthographic projection shows only one side of an object on a principal plane while the other sides will be shown on other principal planes.
2. Orthographic Projection shows you the true size of the object, if you are drawing on 1:1 scale but Isometric Projection do not.
3. Orthographic Projections are drawn at 90 degrees but Isometric projections are drawn at 30 degrees.
4. You need to draw at least the three essential views if you are drawing in Orthographic Projection but for Isometric only one figure is drawn.
5. Orthographic Projection is used for making the objects(with different views) for understanding but Isometric Projection is used to have better understanding of the object with only single view.