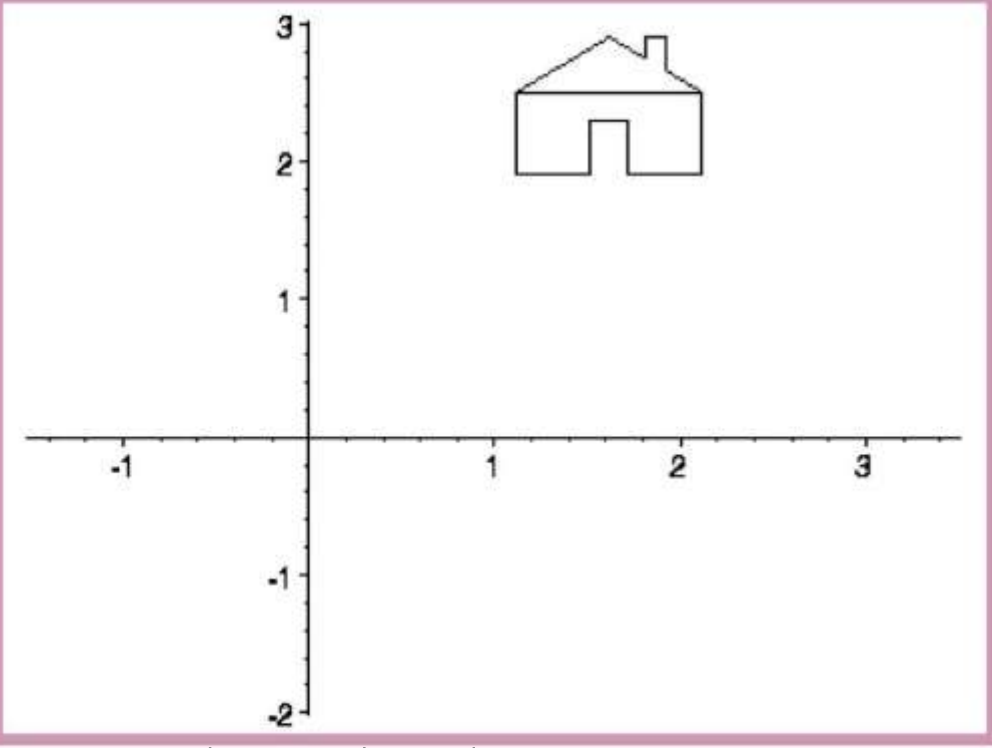
TRANSFORMATION

- Transformations are a fundamental part of the computer graphics. Transformations are the movement of the object in Cartesian plane .



TYPES OF TRANSFORMATION

- There are two types of transformation in computer graphics.
- 1) 2D transformation
- 2) 3D transformation
- Types of 2D and 3D transformation
- 1) Translation
- 2) Rotation
- 3) Scaling
- 4) Shearing
- 5) Mirror reflection

WHY WE USE TRANSFORMATION

- Transformation are used to position objects , to shape object , to change viewing positions , and even how something is viewed.

- In simple words transformation is used for
- 1) Modeling
- 2) viewing

2D TRANSFORMATION

- When the transformation takes place on a 2D plane .it is called 2D transformation.
- 2D means two dimensional (x-axis and Y-axis)

Object Transformation in 2D

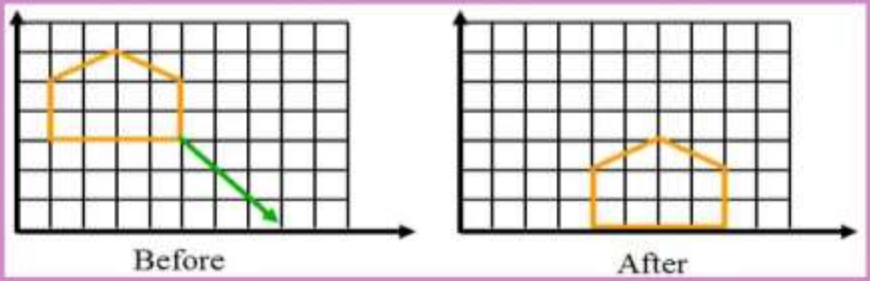
- Alter the coordinates descriptions an object
- Translation , rotation , scaling , shearing,
- reflection.
- Coordinate system unchanged

Coordinate transformation in 2D

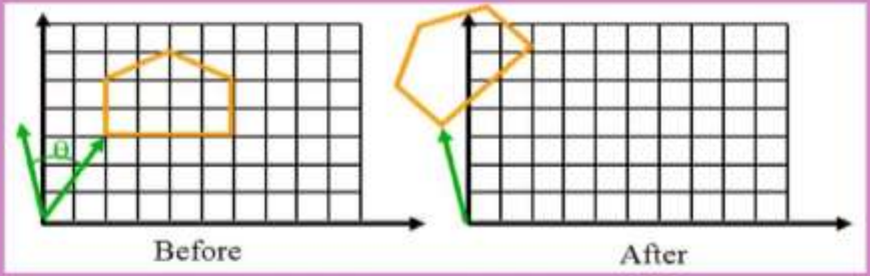
- Produce a different coordinate system

2D TRANSFORMATION

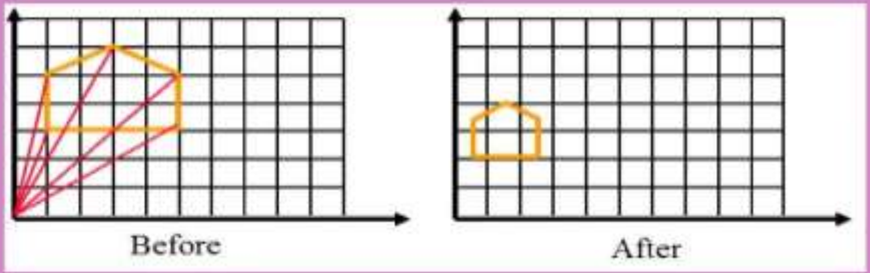
- Translation:-



Rotation:-

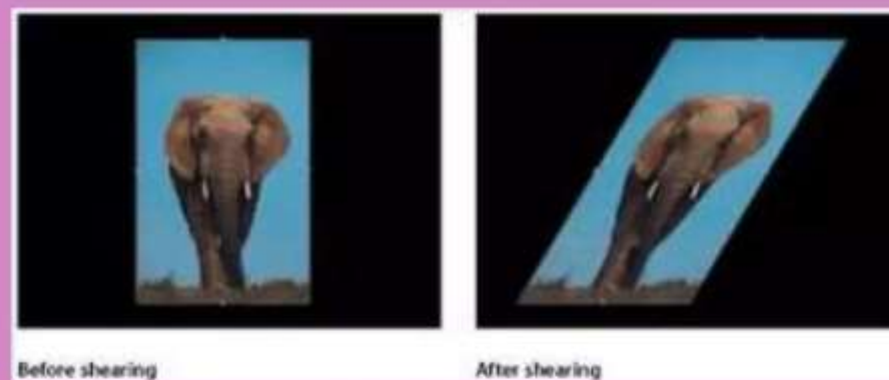


- Scaling:-

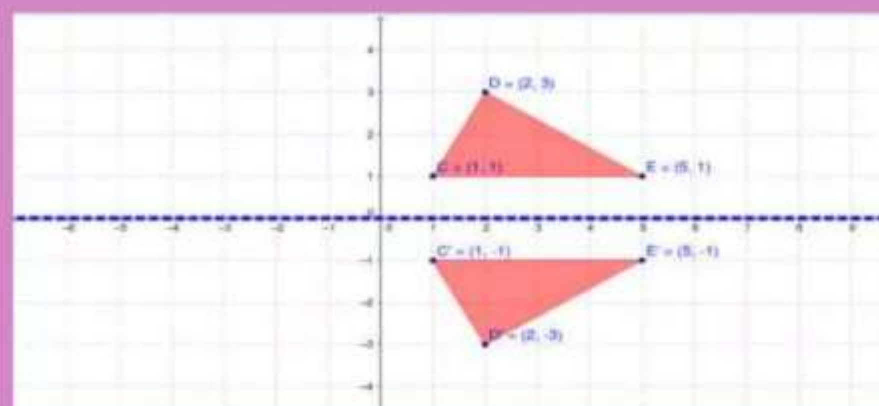


2D TRANSFORMATION

Shearing:-



Reflection



3D TRANSFORMATION

3D TRANSFORMATION

- When the transformation takes place on a 3D plane .it is called 3D transformation.
- Generalize from 2D by including **z** coordinate

Straight forward for translation and scale, rotation more difficult

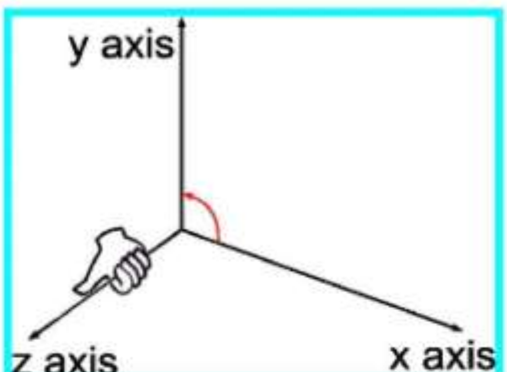
Homogeneous coordinates: 4 components

Transformation matrices: 4×4 elements

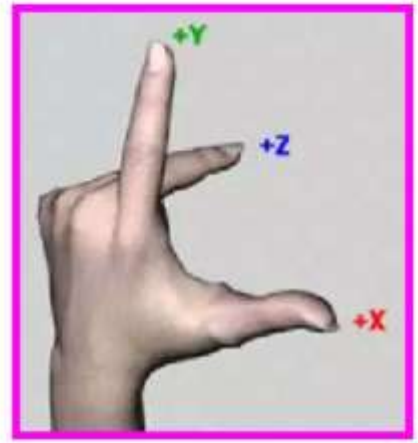
$$\begin{bmatrix} a & b & c & t_x \\ d & e & f & t_y \\ g & h & i & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

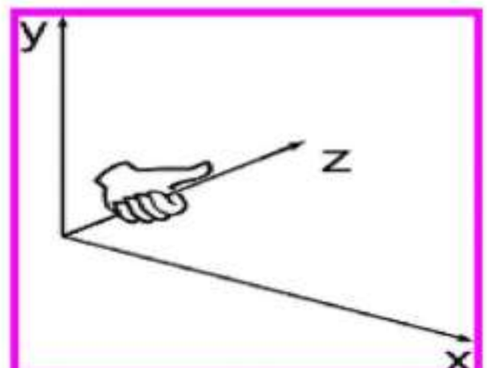
3D COORDINATE SYSTEMS

- ***Right Hand*** coordinate system:



- ***Left Hand*** coordinate system





3D TRANSFORMATION

Point We will consider points as column Vectors . Thus, a typical point with coordinates (x, y, z) is represented as:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

3D Point Homogenous Coordinate

A 3D point **P** is represented in homogeneous coordinates by a 4-dim.

$$\mathbf{P} = \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

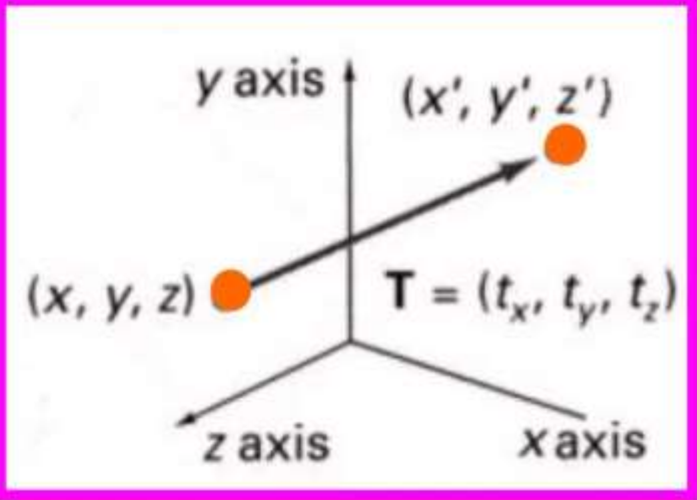
The main advantage:- it is easier to compose translation and rotation

3D TRANSLATION

- Moving of object is called translation.
- In 3 dimensional homogeneous coordinate representation , a point is transformed from position P = (x, y , z) to P'=(x', y', z')
- This can be written as:-

Using P' = T . P

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$



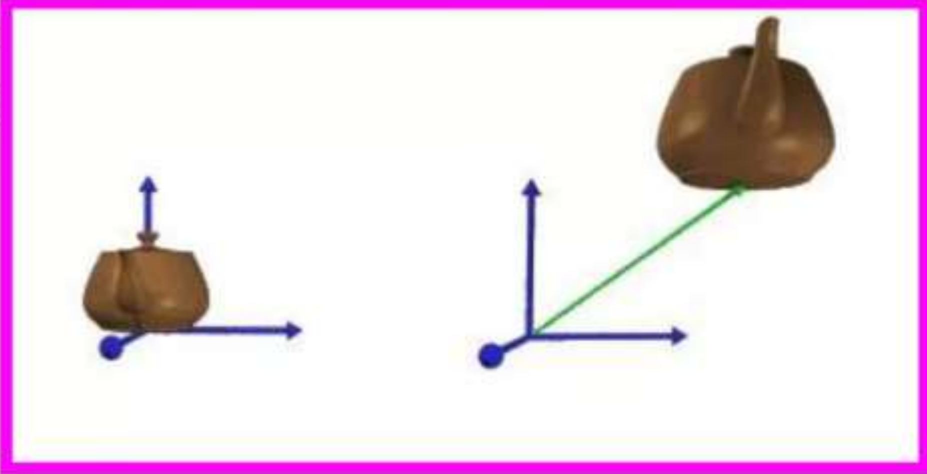
3D TRANSLATION

- The matrix representation is equivalent to the three equation.

$$x' = x + t_x ,\quad y' = y + t_y ,\quad z' = z + t_z$$

Where parameter t_x , t_y , t_z are specifying translation distance for the coordinate direction x , y , z are assigned any real value.

★ Translate an object by translating each vertex in the object.



3D ROTATION

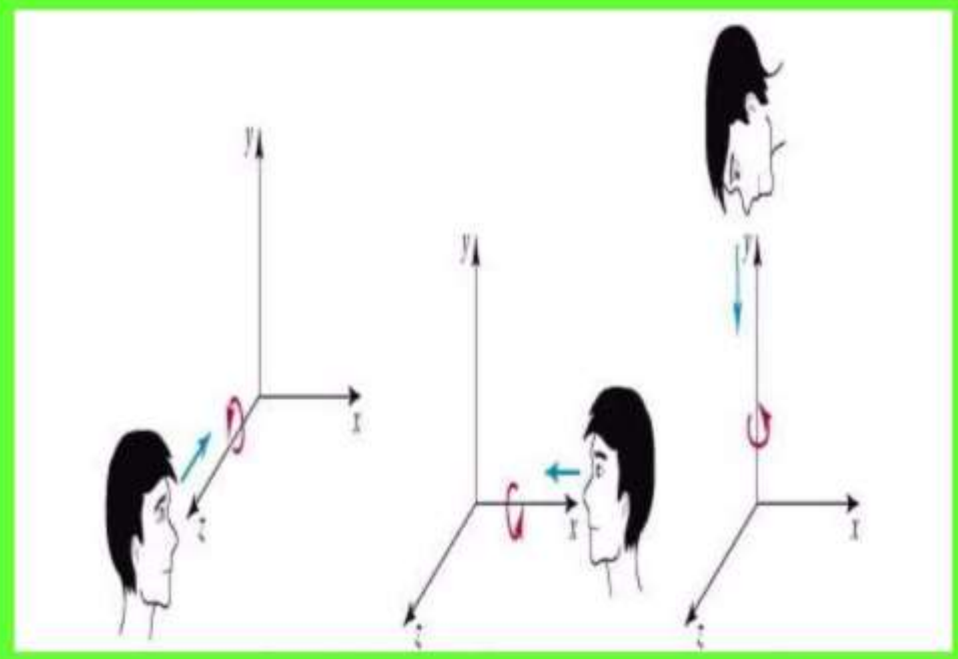
where an object is to be rotated about an axis that is parallel to one of the coordinate axis, we can obtain the desired rotation with the following transformation sequence.

Coordinate axis rotation

Z- axis Rotation(Roll)

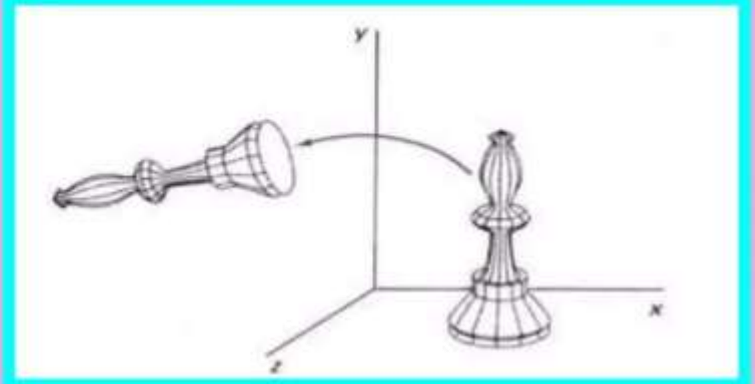
Y-axis Rotation(Yaw)

X-axis Rotation(Pitch)



Z-AXIS ROTATION

Z-axis rotation is same as the origin about in 2D for which we have the derived matrices already.



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

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

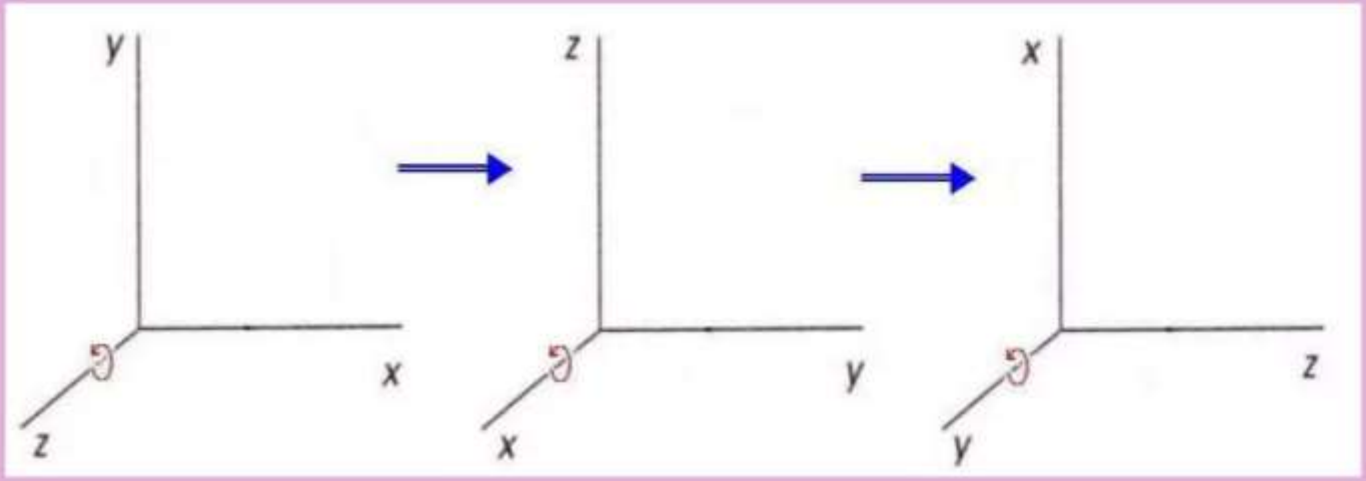
$z' = z$

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

COORDINATE AXIS ROTATION

- Obtain rotations around other axes through cyclic permutation of coordinate parameters:

$$x \rightarrow y \rightarrow z \rightarrow x$$

- 

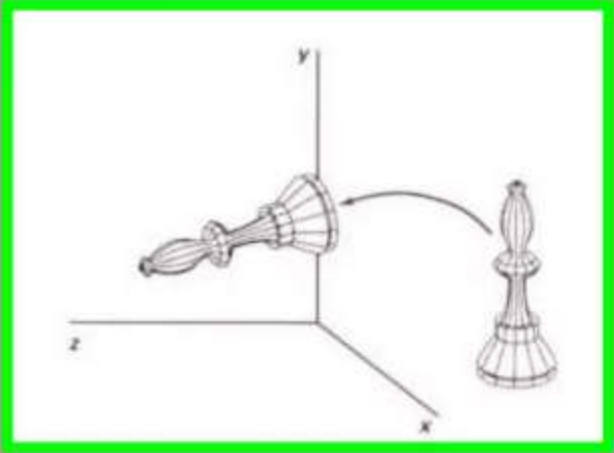
X-AXIS ROTATION

the equation for X-axis rotaion

$x' = x$

$y' = y \cos\theta - z \sin\theta$

$z' = y \sin\theta + z \cos\theta$



$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Y-AXIS ROTATION

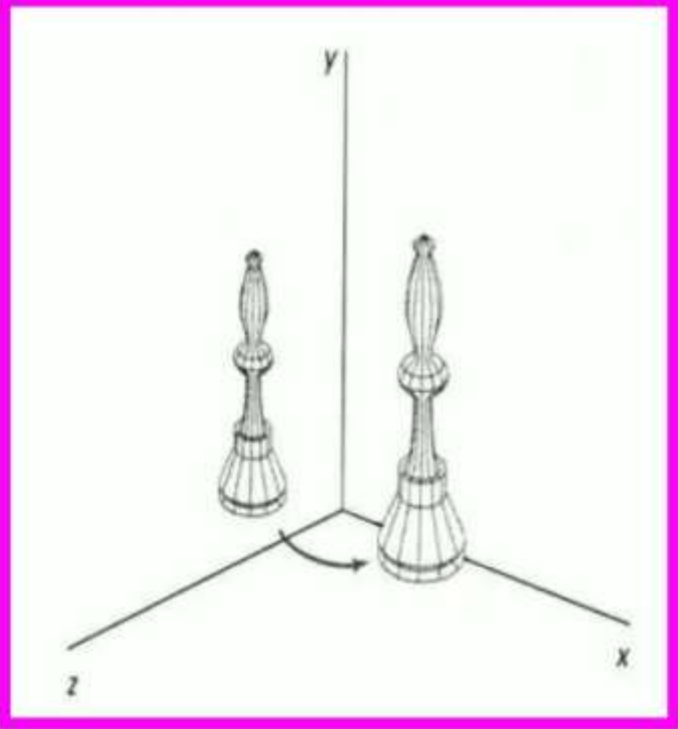
The equation for Y-axis rotaion

x' = x cosθ + z sinθ

y' = y

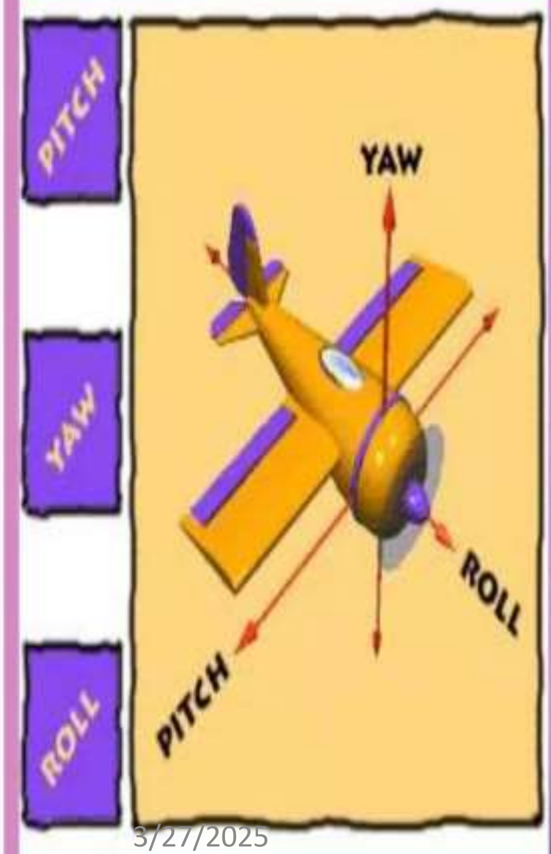
z' = z cosθ - x sinθ

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

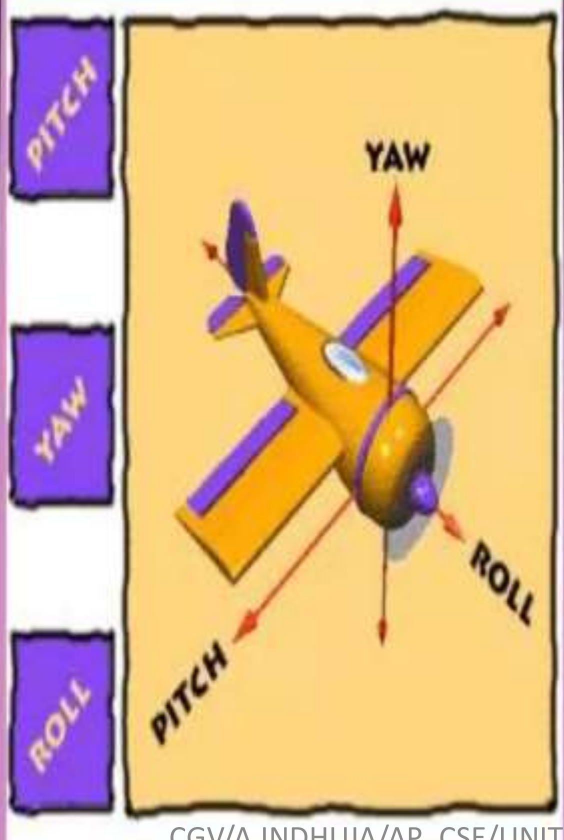


ROLL , PITCH , YAW

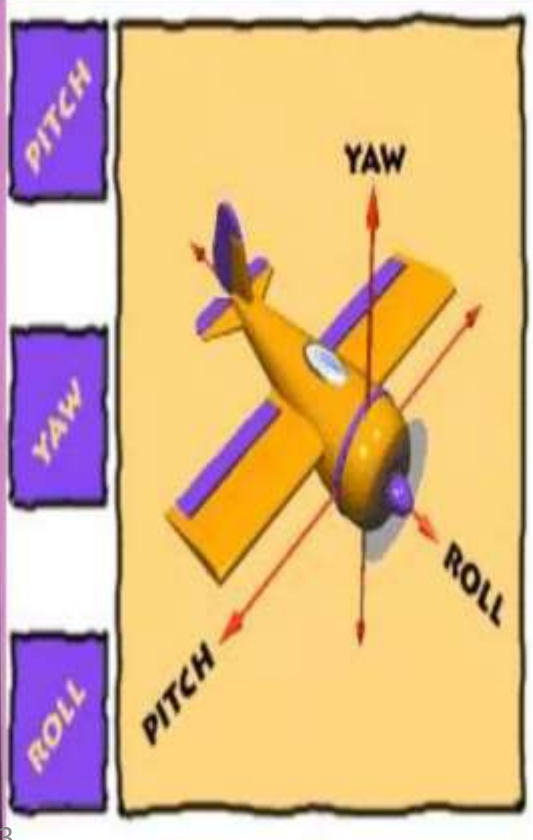
Roll:- Rotation around Front to back (Z-axis)



Pitch :- rotation around the side to side (about x-axis)



Yaw:- rotation around the vertical axis(y-axis)

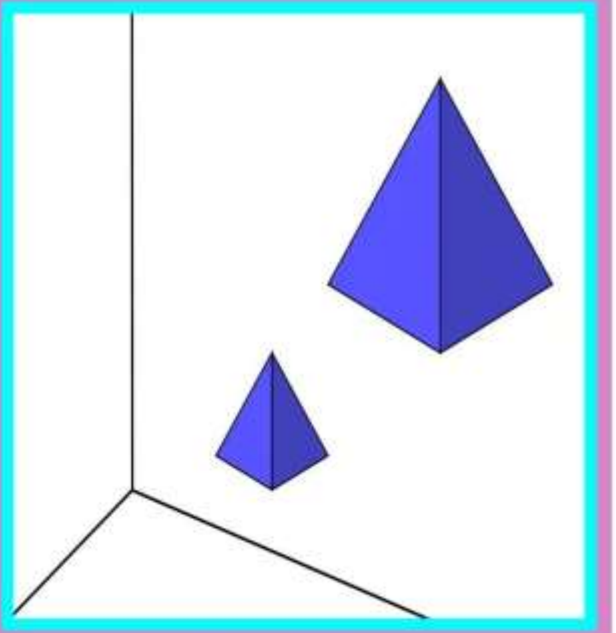


3D SCALING

- Changes the size of the object and repositions the object relative to the coordinate origin.

$$\mathbf{P}' = \mathbf{S} \cdot \mathbf{P}$$

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$



3D SCALING

- The equations for scaling

$$S_{sx,sy,sz} \rightarrow \begin{aligned} x' &= x \cdot sx \\ y' &= y \cdot sy \\ z' &= z \cdot sz \end{aligned}$$

3D REFLECTION

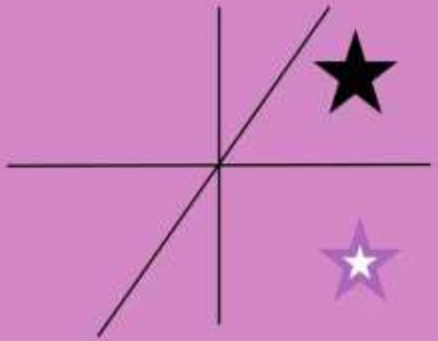
- Reflection in computer graphics is used to emulate reflective objects like mirrors and shiny surfaces
- Reflection may be an x-axis y-axis , z-axis. and also in the planes xy-plane,yz-plane zx-plane.

Reflection relative to a given Axis are equivalent to 180 Degree rotations

3D REFLECTION

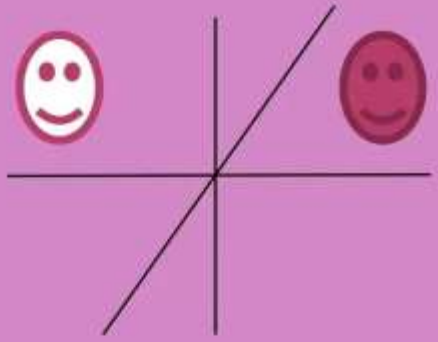
- Reflection about x-axis:-
- x'=x y'=-y z'=-z

$$\begin{vmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix}$$



Reflection about y-axis:-

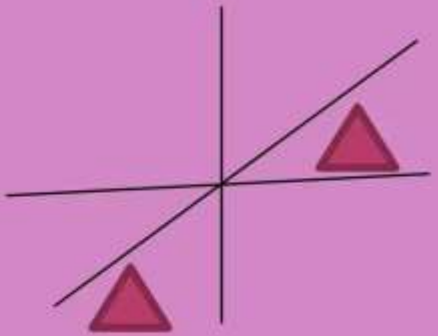
y'=y x'=-x z'=-z



3D REFLECTION

- The matrix for reflection about y-axis:-

$$\begin{vmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix}$$



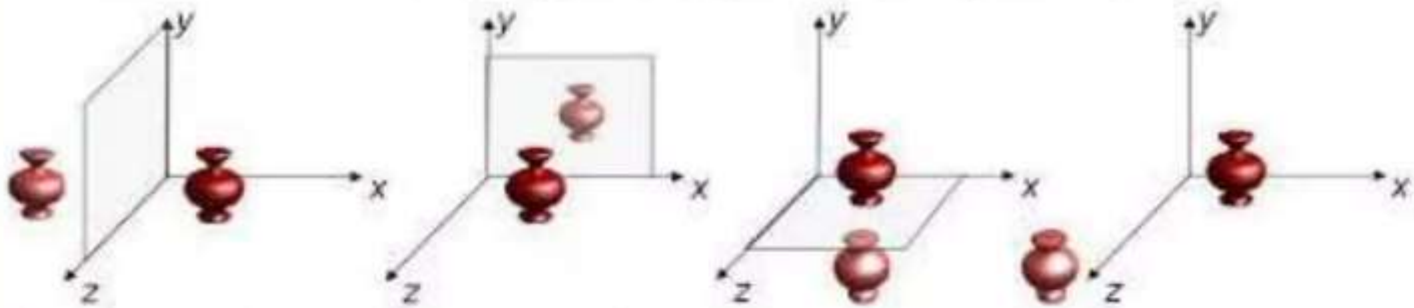
- Reflection about z-axis:-
- $x' = -x \quad y' = -y \quad z' = z$

$$\begin{vmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{vmatrix}$$

3D REFLECTION

Reflection

- Reflection over planes, lines or points



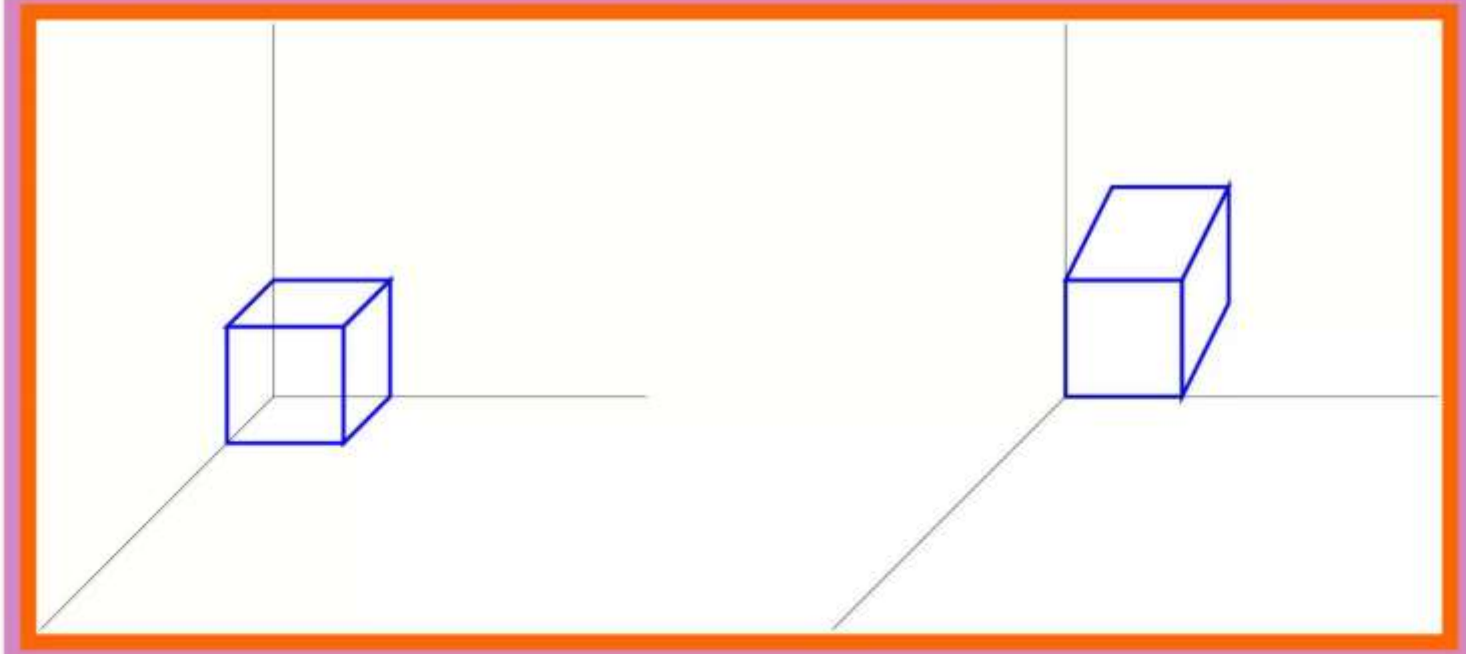
$$\begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}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

3D SHEARING

- **Modify object shapes**
- **Useful for perspective projections**
- When an object is viewed from different directions and at different distances, the appearance of the object will be different. Such view is called perspective view. Perspective projections mimic what the human eyes see.

E.g. draw a cube (3D) on a screen (2D) Alter the values for **x** and **y** by an amount proportional to the distance from z_{ref}

3D SHEARING

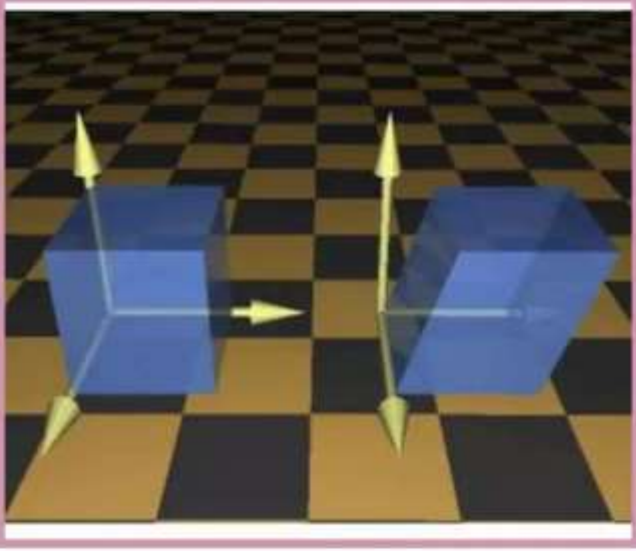


3D SHEARING

- Matrix for 3d shearing
- Where a and b can

Be assigned any real Value.

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & a & 0 \\ 0 & 1 & b & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$




Thank
You