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# Computer Graphics Tutorials

Ans 1: Given,
Rectangular Parallelopiped
with $L_z = 1$ unit
$L_x = 2$ unit
$L_y = 3$ units

After Scaling,
$S_x = 1/2$
$S_y = 1/3$
$S_z = 1$

We get,
$L_z = 1$ unit
$L_x = 1$ unit
$L_y$ 1 unit
Hence, we get a cubic parallelopiped

Ans 2: Given,
Rectangular Parallelopiped
with $L_x = 3$, $L_y = 2$, $L_z = 1$
The matrix representation is:-

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

For rotation about X axis by (-90°)

$$R_x = \begin{bmatrix} \cos(-90) & 0 & 0 & 0 \\ 0 & \cos(-90) & \sin(-90) & 0 \\ 0 & -\sin(-90) & \cos(-90) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

For rotation about Y axis by 90°.

$$R_y = \begin{bmatrix} \cos 90 & 0 & \sin 90 & 0 \\ 0 & 1 & 0 & 0 \\ -\sin 90 & 0 & \cos 90 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Hence,

$$X' = X(R_x R_y)$$

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

1. Given Cube of length 10 units,

$$X = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 10 & 1 \\ 0 & 10 & 0 & 1 \\ 0 & 10 & 10 & 1 \\ 10 & 0 & 0 & 1 \\ 10 & 0 & 10 & 1 \\ 10 & 10 & 0 & 1 \\ 10 & 10 & 10 & 1 \end{bmatrix}$$

Rotate it clockwise about z axis by 45°

$$Rz = \begin{bmatrix} \cos(-45) & \sin(-45) & 0 & 0 \\ -\sin(-45) & \cos(-45) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Scale it by 3 units,

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

$$X' = (X(Rz)(S)) = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 30 & 1 \\ 21.21 & -21.21 & 0 & 1 \\ 21.21 & -21.21 & 30 & 1 \\ -21.21 & -21.21 & 0 & 1 \\ -21.21 & -21.21 & 30 & 1 \\ 0 & -42.42 & 0 & 1 \\ 0 & -42.42 & 30 & 1 \end{bmatrix}$$

Ans 4. View transformation is the mapping of coordinates of points and lines that form the picture into appropriate coordinates on the display device.

World Coordinate System is a right handed cartesian coordinate system where we define the picture to be displayed.

A finite region in the WCS is called a window.

The corresponding coordinate system on the device where the image needs to be displayed is called the physical coordinate system.

The mapping of window onto a subregion of device called the viewport is called Viewing Transformation.

Basically, we use the Normalization Transformation for the same :-

$$N = \begin{bmatrix} S_x & 0 & xV_{min} - S_x xW_{min} \\ 0 & S_y & S_y yW_{min} + yV_{min} \\ 0 & 0 & 1 \end{bmatrix}$$

$$S_x = \frac{xV_{max} - xV_{min}}{xW_{max} - xW_{min}}$$

$$S_y = \frac{yV_{max} - yV_{min}}{yW_{max} - yW_{min}}$$

3D Viewing Pipeline can be explained via the following diagram :-