COMPUTER ENGINEERING

CG ODD SEM 2021-22/EXPERIMENT 6

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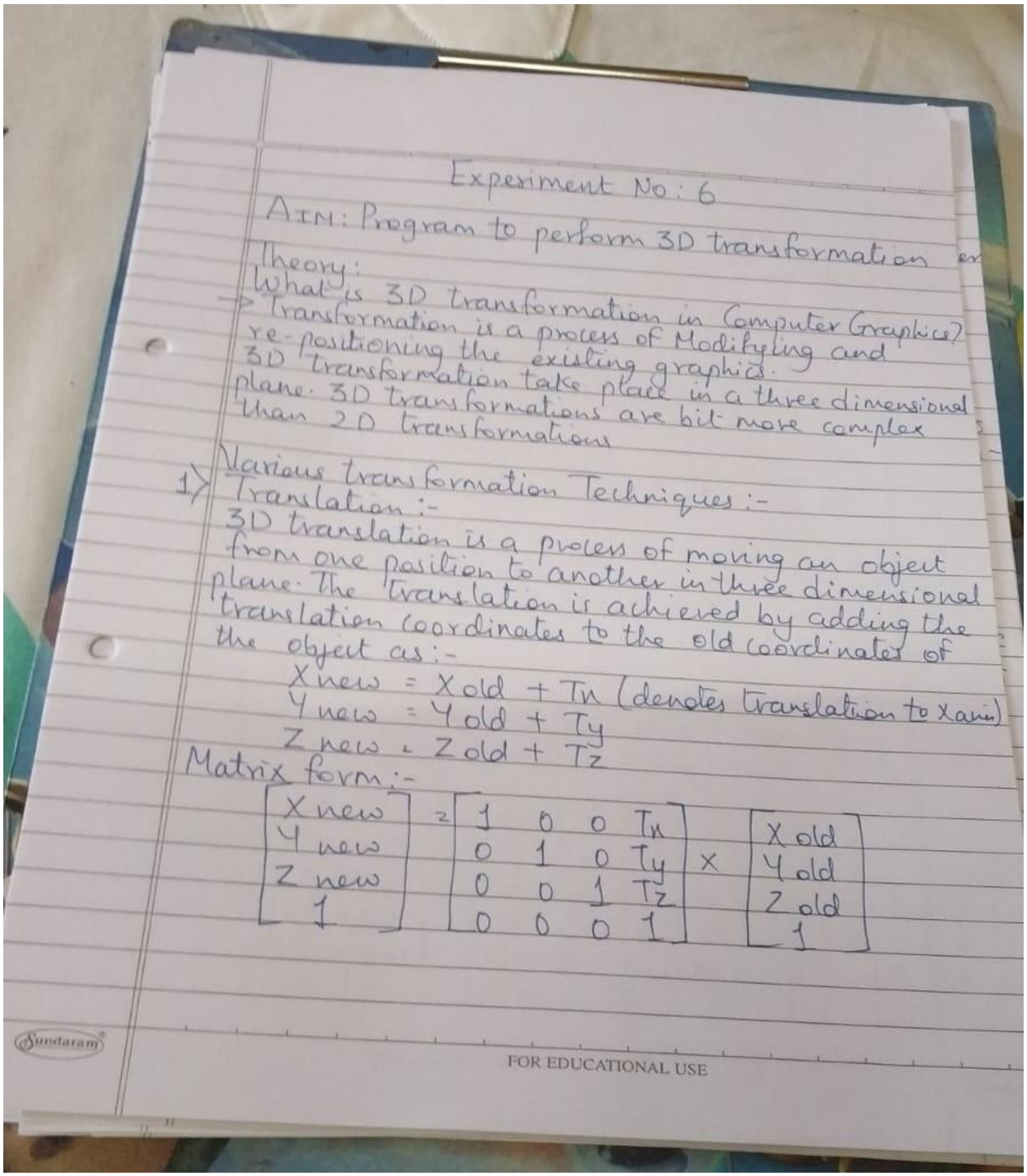

Experiment No: 6

AIM: Program to perform 3D transformation

Theory:

What is 3D transformation in Computer Graphics?

→ Transformation is a process of Modifying and re-positioning the existing graphics. 3D transformation take place in a three dimensional plane. 3D transformations are bit more complex than 2D transformations

1) Various transformation Techniques:-

Translation:-

3D translation is a process of moving an object from one position to another in three dimensional plane. The translation is achieved by adding the translation coordinates to the old coordinates of the object as:-

$X_{new} = X_{old} + T_x$ (denotes translation to x axis)

$Y_{new} = Y_{old} + T_y$

$Z_{new} = Z_{old} + T_z$

Matrix form:-

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

Sundaram

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3) Rotation :-
3D Rotation is the process of rotating an object with respect to an angle in a three dimensional plane.
In 3 dimensions, there are 3 possible types of rotation

a. for X-axis rotation :-
This rotation is achieved by using the following equation :-

$$X_{new} = X_{old}$$
$$Y_{new} = Y_{old} \times \cos\theta - Z_{old} \times \sin\theta$$
$$Z_{new} = Y_{old} \times \sin\theta + Z_{old} \times \cos\theta$$

Matrix form

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & \sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

b. for Y-axis rotation :-
Rotation is achieved by using following equation

$$X_{new} = Z_{old} \times \sin\theta + X_{old} \times \cos\theta$$
$$Y_{new} = Y_{old}$$
$$Z_{new} = Y_{old} \times \cos\theta - X_{old} \times \sin\theta$$

Matrix form :-

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

c) For Z-axis rotation :-

$X_{new} = X_{old} \times \cos\theta - Y_{old} \times \sin\theta$

$Y_{new} = Y_{old} \times \sin\theta + Y_{old} \times \cos\theta$

$Z_{new} = Z_{old}$

Matrix form :-

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

3) Scaling :-

Scaling is the process of modifying or altering the size of the object

In scaling factor > 1, then the object size is increased

In scaling factor < 1, then the object size is reduced

Scaling is achieved by using following equation :-

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

4) Reflection :-

Reflection is kind of rotation where the angle of rotation is 180°. The reflected object is always formed on other side of mirror. The size of reflected object is same as the size of original object. In 3 dimensional there are 3 possible types of reflection :-

1/ Reflection relative to XY plane
2/ Reflection relative to YZ plane
3/ Reflection relative to XZ plane

a. Reflection relative to XY plane:-
This reflection is achieved by

$X_{new} = X_{old}$
$Y_{new} = Y_{old}$
$Z_{new} = -Z_{old}$

Matrix form

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

b. Reflection relative to YZ Plane:-

$X_{new} = -X_{old}$
$Y_{new} = Y_{old}$
$Z_{new} = Z_{old}$

Matrix form

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

c. Reflection relative to XZ Plane :-

$X_{new} = X_{old}$

$Y_{new} = -Y_{old}$

$Z_{new} = Z_{old}$

Matrix form :-

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

5) Shear :-

3D Shearing is an ideal technique to change the shape of existing object in three dimensional plane.

In 3D plane, the object size can be changed along X direction, Y direction as well as Z direction

There are three versions of Shearing :-

a. Shearing in X direction :-

Shearing in X-axis is achieved by using following Shearing equation :-

$X_{new} = X_{old}$

$Y_{new} = Y_{old} + Sh_Y \times X_{old}$

$Z_{new} = Z_{old} + Sh_Z \times X_{old}$

Matrix form

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ Sh_Y & 1 & 0 & 0 \\ Sh_Z & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

b. Shearing in Y-direction :-
Shearing in X-axis is achieved by using :-

$X_{new} = X_{old} + Sh_x * Y_{old}$

$Y_{new} = Y_{old}$

$Z_{new} = Z_{old} + Sh_x \times Y_{old}$

Matrix form:

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & Sh_x & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & Sh_z & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

C. Shearing in Z-direction :-

$X_{new} = X_{old} + Sh_x \times Z_{old}$

$Y_{new} = Y_{old} + Sh_y \times Z_{old}$

$Z_{new} = Z_{old}$

Matrix form

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & Sh_x & 0 \\ 0 & 1 & Sh_y & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

Conclusion :-

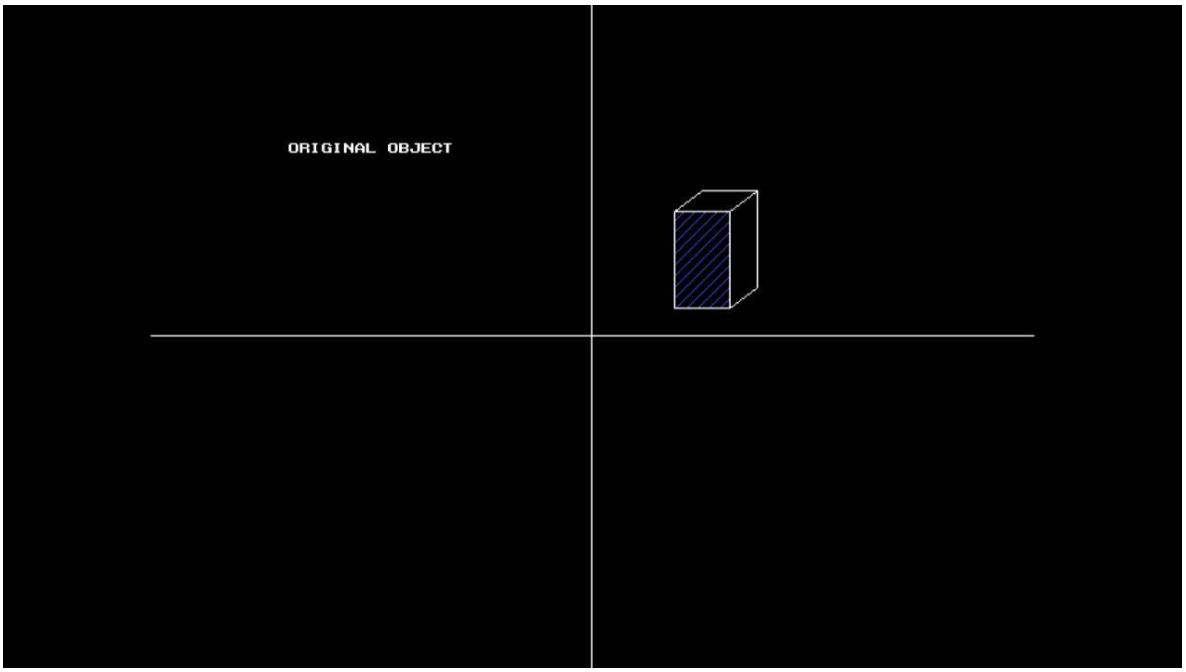
We have successfully performed the lab practical based on 3D transformation and executed the program.

Program:

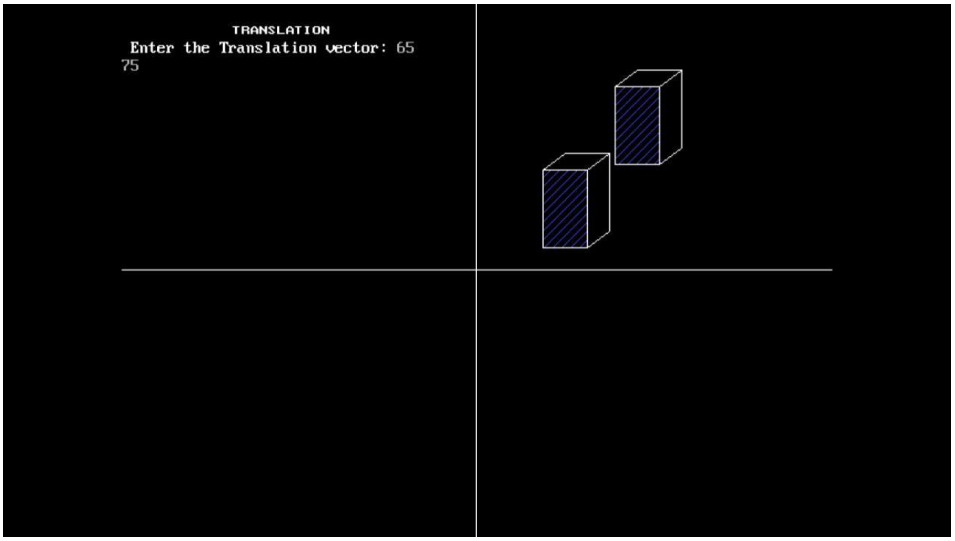
```
#include<stdio.h>
#include<conio.h>
#include<graphics.h>
#include<math.h>

int maxx,maxy,midx,midy;

void axis() {
getch();
cleardevice();
line(midx,0,midx,maxy);
line(0,midy,maxx,midy);
}

void main() {

int gd,gm,x,y,z,ang,x1,x2,y1,y2;
detectgraph(&gd,&gm);
initgraph(&gd,&gm,"C:/TC/BGI");
setfillstyle(3,25);
maxx=getmaxx();
maxy=getmaxy();
midx=maxx/2;
midy=maxy/2;

outtextxy(100,100,"ORIGINAL OBJECT");
line(midx,0,midx,maxy);
line(0,midy,maxx,midy);
bar3d(midx+100,midy-20,midx+60,midy-90,20,5);
axis();

outtextxy(100,20,"TRANSLATION");
printf("\n\n Enter the Translation vector: ");
scanf("%d%d",&x,&y);
bar3d(midx+100,midy-20,midx+60,midy-90,20,5);
bar3d(midx+(x+100),midy-(y+20),midx+(x+60),midy-(y+90),20,5);
axis();

outtextxy(100,20,"SCALING");
printf("\n Enter the Scaling Factor: ");
scanf("%d%d%d",&x,&y,&z);
bar3d(midx+100,midy-20,midx+60,midy-90,20,5);
bar3d(midx+(x*100),midy-(y*20),midx+(x*60),midy-(y*90),20*z,5);
axis();

outtextxy(100,20,"ROTATION");
printf("\n Enter the Rotation angle: ");
scanf("%d",&ang);
x1=100*cos(ang*3.14/180)-20*sin(ang*3.14/180);
y1=100*sin(ang*3.14/180)+20*sin(ang*3.14/180);
x2=60*cos(ang*3.14/180)-90*sin(ang*3.14/180);
y2=60*sin(ang*3.14/180)+90*sin(ang*3.14/180);
axis();

printf("\n After rotating about z-axis\n");
bar3d(midx+100,midy-20,midx+60,midy-90,20,5);
bar3d(midx+x1,midy-y1,midx+x2,midy-y2,20,5);
axis();

printf("\n After rotating about x-axis\n");
bar3d(midx+100,midy-20,midx+60,midy-90,20,5);
bar3d(midx+100,midy-x1,midx+60,midy-x2,20,5);
```

```
axis();

printf("\n After rotating about y-axis\n");
bar3d(midx+100,midy-20,midx+60,midy-90,20,5);
bar3d(midx+x1,midy-20,midx+x2,midy-90,20,5);
axis();

closegraph();
```

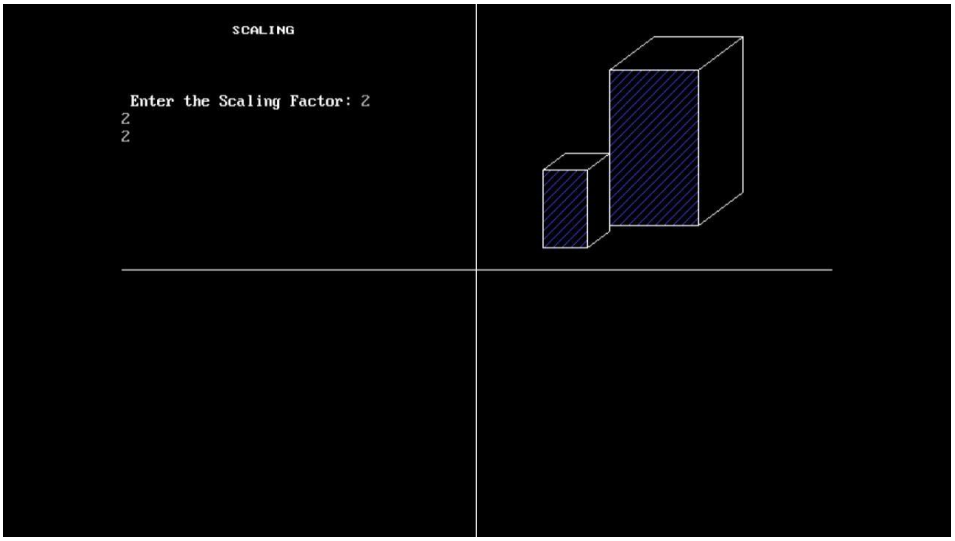
Output:



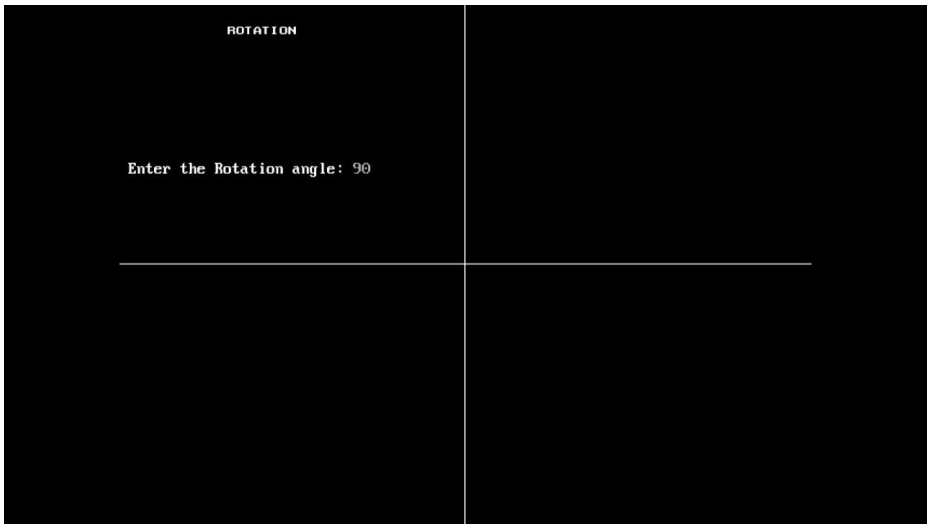
1. TRANSLATION:-

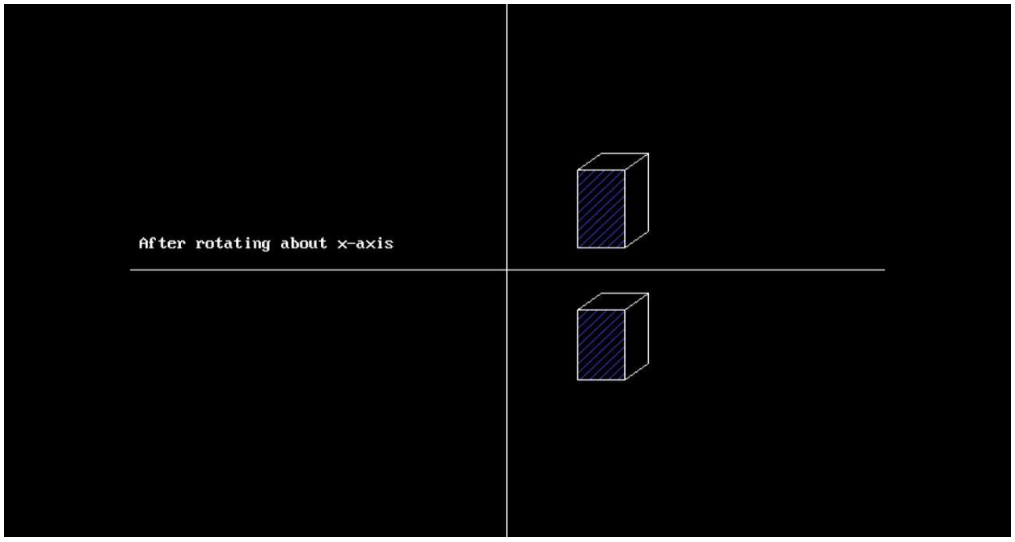


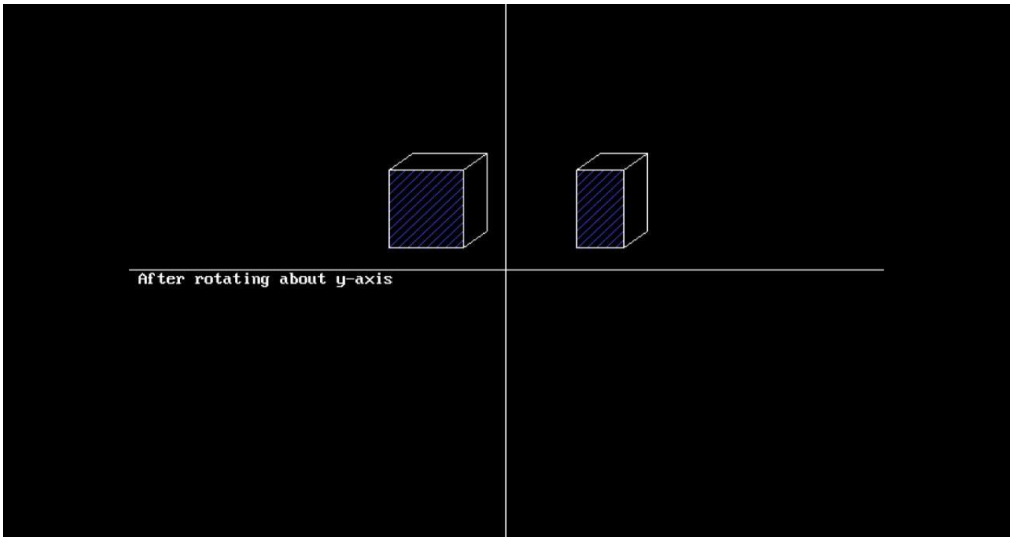
2. SCALING:-



3. ROTATION:-




After rotating about x-axis


After rotating about y-axis