# COMPUTER GRAPHICS

THIRD CLASS

University of Diyala/ College of education for pure science / Computer science department

**23/02/2018**

# 3. Two-Dimensional Transformation (Part 2-2)

## 4- Mirroring (Reflection):

Mirroring is a convenient method used for copying an object while preserving its features. The mirror transformation is a special case of a negative non-uniform scaling.

If either the X or Y axis is treated as a mirror, the object has a mirror image or reflection. The reflected point Pnew is located the same distance from the mirror (the axis) as the original point P.

4-1:Reflection on the X axis:

| | | | |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 0 | -1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

OR Xnew= X
Ynew= -Y

4-2:Reflection on the Y axis:

| | | | |
|---|---|---|---|
| -1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

OR Xnew= - X
Ynew= Y

4-3:Reflection on the origin:

| | | | |
|---|---|---|---|
| -1 | 0 | 0 | 0 |
| 0 | -1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

OR Xnew= - X

Ynew= -Y

Example 1: Reflect the point P(3,2): a) X axis b) Y axis c ) Origin
Solution : a

Solution : a-

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

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

b-

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

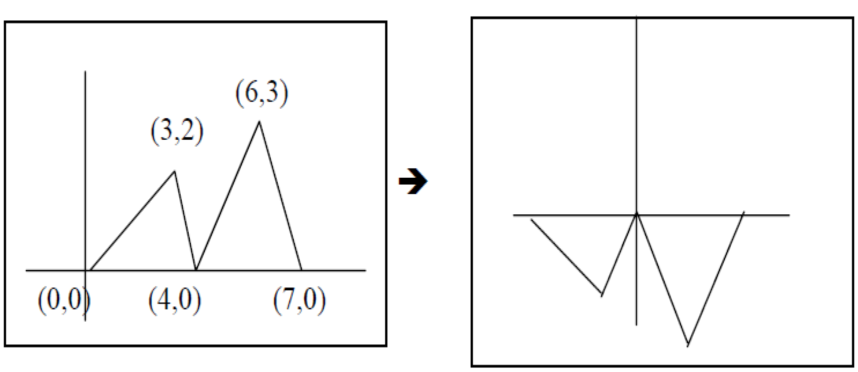
$$= \begin{bmatrix} -3 & 2 & 1 \end{bmatrix}$$

c-

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

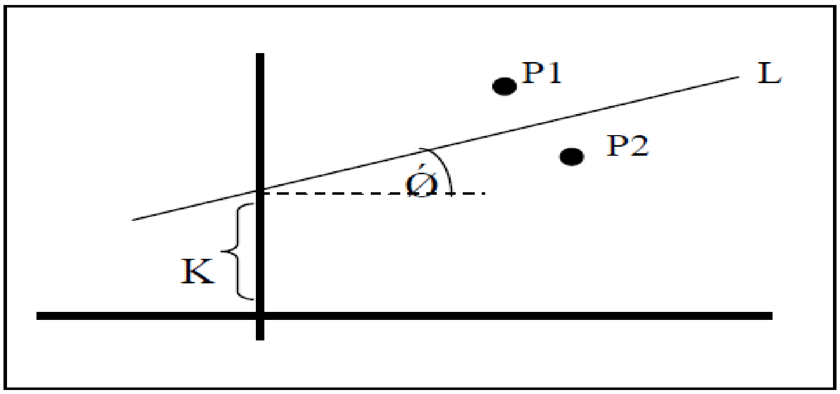
$$= \begin{bmatrix} -3 & -2 & 1 \end{bmatrix}$$

H.W : What (4*4) matrix will change the center of the scene to the origin, and reflect the mountains in the lake? [the center of the scene is (4,0) ] .



**4-1 Mirroring(reflection) About an Arbitrary line**

To reflect an object on a line that does not pass through the origin, which is the general case:




As shown in the figure, let the line L intercept with Y axis in the point (0,K) and have an angle of inclination Ǿ degree with respect to the positive direction of X axis . To reflect the point P1 on the line L, we follow the following steps:

1- Move all the points up or down (in the direction of Y axis) so that L pass through the origin

***T=***

| | | | |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | -K | 0 | 1 |

2- Rotate all the points through (-Ǿ) degree about the origin making L lie along the X axis

***R=***

| | | | |
|---|---|---|---|
| cosØ | -sinØ | 0 | 0 |
| sinØ | cosØ | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

3- Reflect the point P1 on the X axis:

***RefX=***

| | | | |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 0 | -1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

4- Rotate back the points by (-Ǿ) degree so that L back to its original rientation

$R^{-1}$ =

| | | | |
|---|---|---|---|
| cosØ | sinØ | 0 | 0 |
| -sinØ | cosØ | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

5- Shift in the direction of Y axis so that L is back in its original position

$T^{-1}$ =

| | | | |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | K | 0 | 1 |

The sequence of matrices needed to perform this non-standard reflection is :

S= T * R * RefX * R -1 * T -1

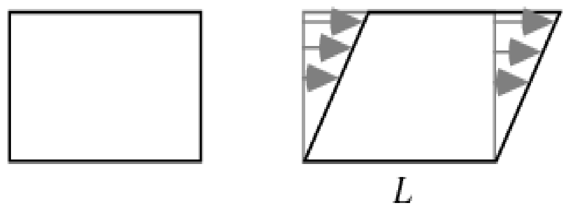
***S =***

| | | | |
|---|---|---|---|
| Cos 2Ø | Sin2Ø | 0 | 1 |
| Sin2Ø | -cos2Ø | 0 | 1 |
| -kSin2Ø | K+kcos2Ø | 1 | 1 |
| 0 | 0 | 0 | 1 |

**Then** **[P*] = [P] * S**

***H.W*** : Find the single matrix that causes all the points in the plane to be reflected about the line with equation $y = 0.5x + 2$, then apply this matrix to reflect the triangle with vertices at A(2,4), B(4,6), C(2,6) about that line.

## 5-Shearing




A transformation in which all points along a given line L remain fixed while other points are shifted parallel to L by a distance proportional to their perpendicular distance from L. Shearing a plane figure does not change its area.

There are two types of shearing

**1- <u>Y shearing</u>**

It transforms the point (X,Y) to the point (Xnew,Ynew) where

Xnew= X

Ynew= Y+Shy * X where Shy≠0

The matrix is :

| | | | |
|---|---|---|---|
| 1 | Shy | 0 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

Y shearing moves a vertical line up or down depending on the sign of the shear factor ***Shy***. A horizontal line is distorted into a line with slop ***Shy***. And vis versa.

**<u>2- X shearing</u>**

It transform the point (X,Y) to the point (Xnew,Ynew) where

Xnew= X+Shx * Y where Shy≠0

Ynew= Y

The matrix is

| | | |
|---|---|---|
| 1 | 0 | 0 |
| Shx | 1 | 0 |
| 0 | 0 | 1 |

Example : Share the object (1,1) , (3,1) , (1,3) , (3,3) with
a: Shx=2
b: Shy=2

Solution : a: Shx=2

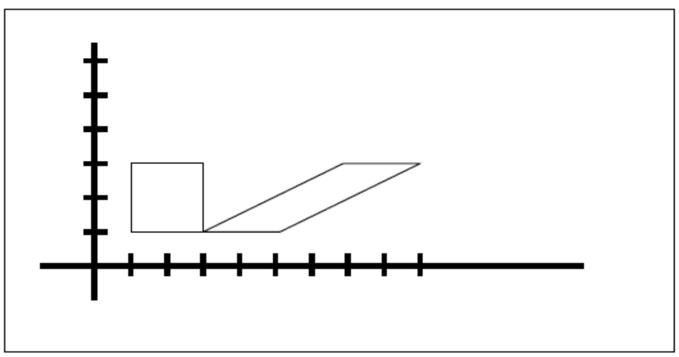
| | | |
|---|---|---|
| 1 | 1 | 1 |
| 3 | 1 | 1 |
| 1 | 3 | 1 |
| 3 | 3 | 1 |

*

| | | |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 1 | 0 |
| 0 | 0 | 1 |

=

| | | |
|---|---|---|
| 3 | 1 | 1 |
| 5 | 1 | 1 |
| 7 | 3 | 1 |
| 9 | 3 | 1 |



b- Shy

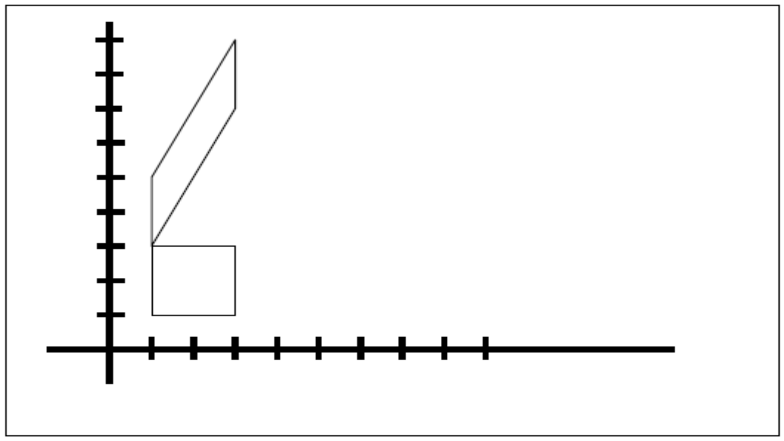
| | | |
|---|---|---|
| 1 | 1 | 1 |
| 3 | 1 | 1 |
| 1 | 3 | 1 |
| 3 | 3 | 1 |

*

| | | |
|---|---|---|
| 1 | 2 | 0 |
| 0 | 1 | 0 |
| 0 | 0 | 1 |

=

| | | |
|---|---|---|
| 1 | 3 | 1 |
| 3 | 7 | 1 |
| 1 | 5 | 1 |
| 3 | 9 | 1 |



Quiz: Generate figure 2 form figure 1 using matrices .

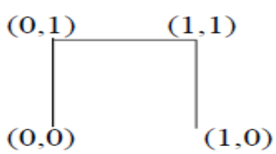



Figure 1

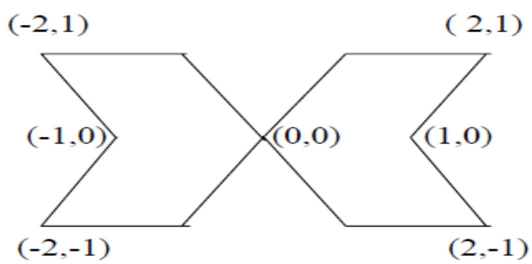



Figure 2