
KTU
NOTES

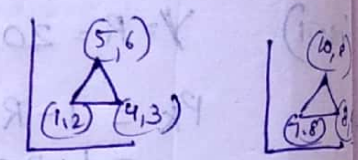
Module-2
Basic 2D transformation

① Translation

To transfer the object from one place to another

$(x, y) \leftarrow$ original position

$t_x, t_y \leftarrow$ translation vector.



$$\boxed{\begin{aligned} x' &= x + t_x \\ y' &= y + t_y \end{aligned}} \leftarrow \text{New position}$$

Matrix representation

$$P = \begin{bmatrix} x \\ y \end{bmatrix} \qquad T = \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

$$P' = \begin{bmatrix} x' \\ y' \end{bmatrix}$$

$$\boxed{P' = P + T}$$

Qn) Given a circle with radius 10 and centre coordinates (1,4). Apply the translation in the distance 5 towards x-axis and 1 towards y-axis. obtain the loop coordinates without changing the radius.

$(x, y) = (1, 4)$

$(t_x, t_y) = (5, 1)$

$x' = x + t_x$

$= 1 + 5 = 6$

$y' = y + t_y$

$= 4 + 1 = 5$

∴ Matrix representation

$$P' = \begin{bmatrix} 6 \\ 5 \end{bmatrix}$$

$$P = \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 1 \\ 4 \end{bmatrix}$$

$$T = \begin{bmatrix} t_x \\ t_y \end{bmatrix} = \begin{bmatrix} 5 \\ 1 \end{bmatrix}$$

② <u>Scaling</u> (alteration in the shape of the object)

$(x, y) \leftarrow$ original coordinates

$(S_x, S_y) \leftarrow$ scaling parameter

$$\boxed{\begin{aligned} x' &= x \cdot S_x \\ y' &= y \cdot S_y \end{aligned}}$$

<u>Matrix representation</u>

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

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

Qn) Given a square with coordinate points A(0,3), B(3,3), C(3,0), D(0,0). Apply the scale parameter 2 towards x-axis and 3 towards y-axis. and obtain the new coordinates.

$(x,y) = (0,3)$
$(S_x, S_y) = (2,3)$

$x' = x \cdot S_x$
$= 0 \times 2 = 0$

$y' = y \cdot S_y$
$= 3 \times 3 = 9$

$(x,y) = (3,3)$
$(S_x, S_y) = (2,3)$

$x' = x \cdot S_x$
$= 3 \times 2 = 6$

$y' = y \cdot S_y$
$= 3 \times 3 = 9$

$(x,y) = (3,0)$
$(S_x, S_y) = (2,3)$

$x' = x \cdot S_x$
$= 3 \times 2 = 6$

$y' = y \cdot S_y$
$= 0 \times 3 = 0$

$(x,y) = (0,0)$
$(S_x, S_y) = (2,3)$

$x' = x \cdot S_x$
$= 0 \times 2 = 0$

$y' = y \cdot S_y$
$= 0 \times 3 = 0$

Matrix representation

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

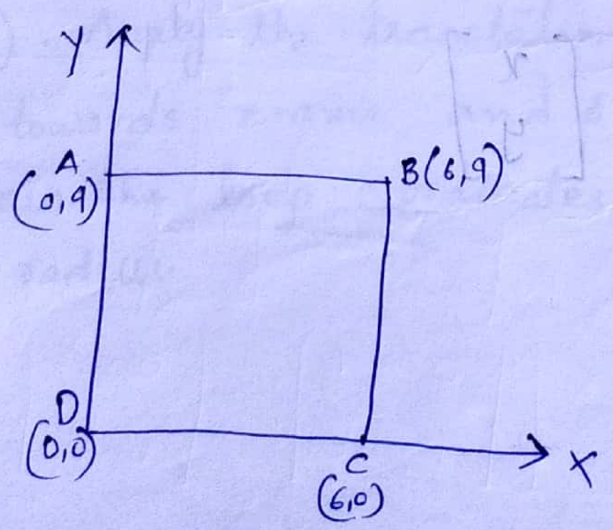
$$= \begin{bmatrix} 2 & 0 \\ 0 & 3 \end{bmatrix} \begin{bmatrix} 0 \\ 3 \end{bmatrix}$$

$$= \begin{bmatrix} 0+0 \\ 9 \end{bmatrix} = \begin{bmatrix} 0 \\ 9 \end{bmatrix}$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 6 \\ 9 \end{bmatrix}$$

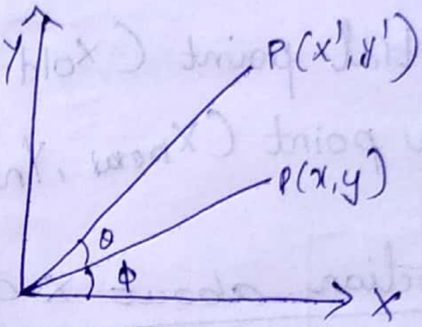
$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 6 \\ 0 \end{bmatrix}$$

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



(3) Rotation

Repositioning along a circular path.



$x = r\cos\phi$ ——— (1)

$y = r\sin\phi$ ——— (2)

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

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

$x' = r\cos\phi\cos\theta - r\sin\phi\sin\theta$

$y' = r\cos\phi\sin\theta + r\sin\phi\cos\theta$

From (1) & (2)

$$\boxed{\begin{aligned} x' &= x\cos\theta - y\sin\theta \\ y' &= x\sin\theta + y\cos\theta \end{aligned}}$$

Matrix representation

$P' = R \cdot P$

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

$P'^T = (R \cdot P)^T$

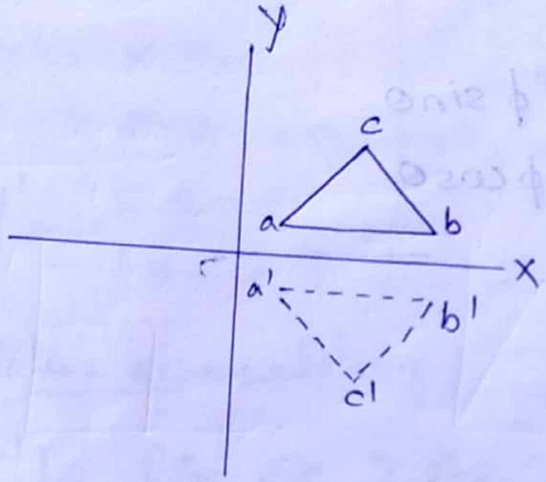
$= P^T \cdot R^T$

4 Reflection

Rotation about 180°

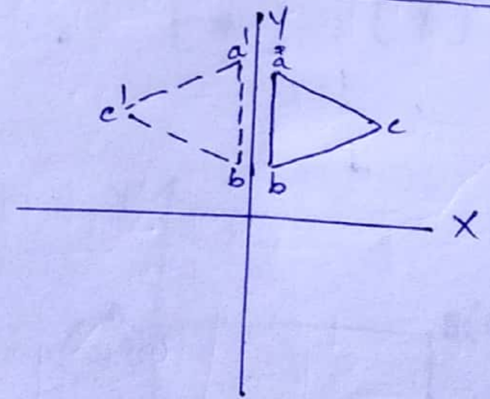
- initial point (x_{old}, y_{old})
- new point (x_{new}, y_{new})

Reflection about x-axis



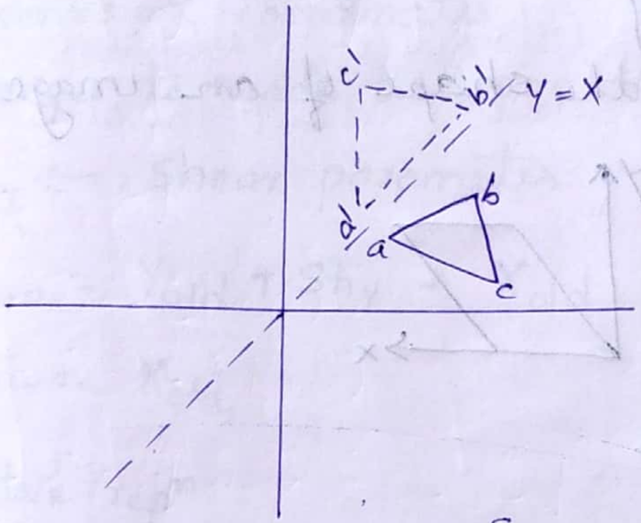
$$\begin{bmatrix} x_{new} \\ y_{new} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_{old} \\ y_{old} \end{bmatrix}$$

Reflection about y-axis



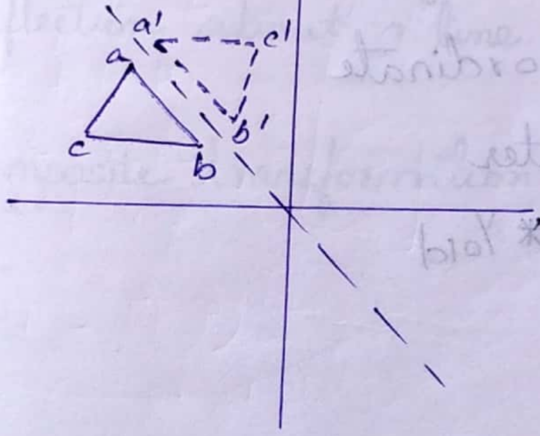
$$\begin{bmatrix} x_{new} \\ y_{new} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_{old} \\ y_{old} \end{bmatrix}$$

Reflection about $Y = X$



$$\text{Reflection matrix} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_{old} \\ Y_{old} \\ 1 \end{bmatrix} = \begin{bmatrix} X_{new} \\ Y_{new} \\ 1 \end{bmatrix}$$

Reflection about $Y = -X$



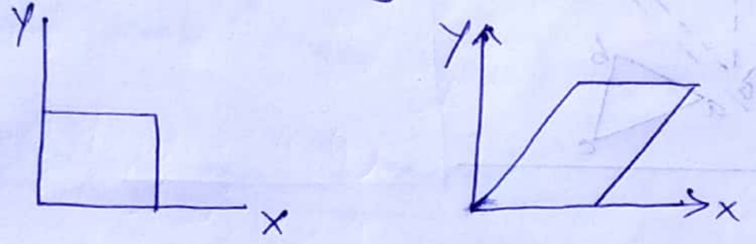
$$\text{Reflection matrix} = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_{old} \\ Y_{old} \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} X_{new} \\ Y_{new} \\ 1 \end{bmatrix}$$

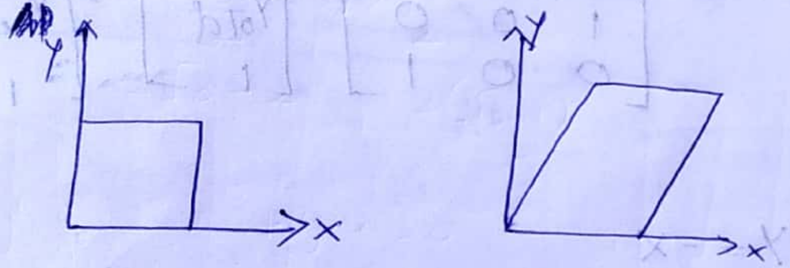
(5) Shear

Also called skewing

It is the slanting the shape of an image.



X shear



- Preserves Y coordinate
- Changes made to X coordinate

$Sh_x \leftarrow$ Shear parameter

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

$Y_{new} = Y_{old}$

Matrix representation

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} 1 & sh_x \\ 0 & 1 \end{bmatrix} \begin{bmatrix} X_{old} \\ Y_{old} \end{bmatrix}$$

Y shear

Preserves X coordinates

Changes to made to Y coordinate

$Sh_y \leftarrow$ Shear parameter

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

$$X_{new} = X_{old}$$

Matrix repⁿ

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

Assignment {on wednesday}

① Reflection about origin
Reflection about a line

② Composite transformation

Q1) Given a line segment with a line segment starting point (0,0) and ending point (4,4). Apply 30° rotation anticlockwise direction on the line segment and find out the new coordinates of the line.

Ans: $(X_{old}, Y_{old}) = (4,4)$

$\theta = 30^\circ$

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

$= 4\cos 30 - 4\sin 30$

$= 4 \times \frac{\sqrt{3}}{2} - 4 \times \frac{1}{2}$

$= 2\sqrt{3} - 2 = \boxed{2(\sqrt{3}-1)}$

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

$= 4\sin 30 + 4\cos 30$

$= 4 \times \frac{1}{2} + 4 \times \frac{\sqrt{3}}{2}$

$= 2 + 2\sqrt{3}$

$= 2(1+\sqrt{3})$

3D Transformation

Translation

$X_{new} = X_{old} + t_x$

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

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

*Matrix Rep^n

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

Qn Given a 3-D object with coordinate points A(0,3,1), B(3,3,2), C(3,0,0), D(0,0,0). Apply the translation with 1 towards x-axis, 1-towards y-axis and 2-towards z-axis. Obtain the new coordinates of the object.

~~$(X_{old}, Y_{old}, Z_{old}) = (1,$~~

Ans: $X_{new} = X_{old} + t_x$

$(t_x, t_y, t_z) = (1, 1, 2)$

A(0,3,1)

$X_{new} = 0 + 1 = 1$

$Y_{new} = 3 + 1 = 4$

$Z_{new} = 1 + 2 = 3$

Matrix representation

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 3 \\ 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 \\ 4 \\ 3 \\ 1 \end{bmatrix}$$

B(3,3,2)

$X_{new} = 3+1 = 4$

$Y_{new} = 3+1 = 4$

$Z_{new} = 2+2 = 4$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 3 \\ 3 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 4 \\ 4 \\ 4 \\ 1 \end{bmatrix}$$

C(3,0,0)

$X_{new} = 3+1 = 4$

$Y_{new} = 0+1 = 1$

$Z_{new} = 0+2 = 2$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 3 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 4 \\ 1 \\ 2 \\ 1 \end{bmatrix}$$

D(0,0,0)

$X_{new} = 0+1 = 1$

$Y_{new} = 0+1 = 1$

$Z_{new} = 0+2 = 2$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 2 \\ 1 \end{bmatrix}$$

Scaling

$S_x, S_y, S_z \Leftarrow$ Scaling parameter (SP)

$X_{new} = X_{old} \cdot S_x$

$Y_{new} = Y_{old} \cdot S_y$

$Z_{new} = Z_{old} \cdot S_z$

If S.P >1, object size increases

SP <1, object size decreases

Matrix Representation

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

Q1) Given a 3-D object with coordinate points A(0,3,3) B(3,3,6) C(3,0,1) D(0,0,0). Apply the scaling parameter 2 towards x-axis, 3 towards y-axis and 3 towards z-axis. Obtain the new coordinates of the object.

$(S_x, S_y, S_z) = (2,3,3)$

A(0,3,3)

$X_{new} = 0 \times 2 = 0$

$Y_{new} = 3 \times 3 = 9$

$Z_{new} = 3 \times 3 = 9$

Matrix repⁿ

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 3 \\ 3 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 9 \\ 9 \\ 1 \end{bmatrix}$$

B(3,3,6)

$X_{new} = 3 \times 2 = 6$

$Y_{new} = 3 \times 3 = 9$

$Z_{new} = 6 \times 3 = 18$

Matrix repⁿ

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 3 \\ 3 \\ 6 \\ 1 \end{bmatrix} = \begin{bmatrix} 6 \\ 9 \\ 18 \\ 1 \end{bmatrix}$$

C(3,0,1)

$X_{new} = 3 \times 2 = 6$

$Y_{new} = 0 \times 3 = 0$

$Z_{new} = 1 \times 3 = 3$

Matrix repⁿ

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 3 \\ 0 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 6 \\ 0 \\ 3 \\ 1 \end{bmatrix}$$

$D(0,0,0)$

$X_{new} = 0 \times 2 = 0$

$Y_{new} = 0 \times 3 = 0$

$Z_{new} = 0 \times 3 = 0$

Matrix rep^n

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

Rotation

X-axis

$X_{new} = X_{old}$

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

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

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

Y-axis

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

$Y_{new} = Y_{old}$

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

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

Z-axis

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

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

$Z_{new} = Z_{old}$

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

1) Given a homogeneous point (1,2,3). Apply rotation 90 towards X, Y and z axis and find out the new coordinates

X-axis

$(X_{old}, Y_{old}, Z_{old}) = (1,2,3)$

$X_{new} = X_{old} = 1$

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

$= 2\cos 90^\circ - 3\sin 90$

$= 2\times 0 - 3 = \underline{\underline{-3}}$

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

$= 2\sin 90 + 3\cos 90^\circ$

$= 2 + 0 = \underline{\underline{2}}$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 1 \end{bmatrix} \Rightarrow \begin{bmatrix} 1 \\ -3 \\ 2 \\ 1 \end{bmatrix}$$

Y-axis

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

$= 3 \sin 90 + 1 \cos 90$

$= \underline{\underline{3}}$

$Y_{new} = Y_{old} = \underline{2}$

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

$= 2 \cos 90 - 1 \sin 90$

$= \underline{\underline{-1}}$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 1 \end{bmatrix}$$

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

Z-axis

$X_{new} = 1 \cos 90 - 2 \sin 90$

$= -2 \times 1 = -2$

$Y_{new} = 1 \sin 90 + 2$

$= 1 + 2 = 3$

$Z_{new} = 3$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 1 \end{bmatrix} \Rightarrow \begin{bmatrix} -2 \\ 3 \\ 3 \\ 1 \end{bmatrix}$$

Q1) Given a triangle with coordinate points A(3,4) B(6,4) C(5,6). Apply the reflection of x-axis and obtain the new coordinates

Ans. A (3,4)

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} X_{old} \\ Y_{old} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 3 \\ 4 \end{bmatrix} = \begin{bmatrix} 3 \\ -4 \end{bmatrix}$$

$X_{new} = X_{old}$

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

$\therefore X_{new} = 3$

$Y_{new} = -4$

B (6,4)

$X_{new} = 6$

$Y_{new} = -4$

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} 6 \\ -4 \end{bmatrix}$$

C(5,6)

$X_{new} = 5$

$Y_{new} = -6$

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} 5 \\ -6 \end{bmatrix}$$

Qn) Given a triangle with points (1,1) (0,0) (1,0). Apply shear parameter 2 on x-axis and 2 on y-axis and find out the new coordinates.

Ans:. X - axis shear A(1,1)

$X_{new} = 1 + 2 * 1$
$= 1 + 2 = 3$

$Y_{new} = 1$

Matrix repn

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

Y - axis shear

$X_{new} = 1$

$Y_{new} = 1 + 2 * 1$
$= 1 + 2 = 3$

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

B (0,0)

X shear

$X_{new} = 0 + 2 \times 0 = 0$

$Y_{new} = 0$

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Y- shear

$x_{new} = 0$

$y_{new} = 0 + 2 \times 0 = 0$

$$\begin{bmatrix} x_{new} \\ y_{new} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

C(1,0)

x-shear

$x_{new} = 1 + 2 \times 0 = 1$

$y_{new} = 0$

$$\begin{bmatrix} x_{new} \\ y_{new} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

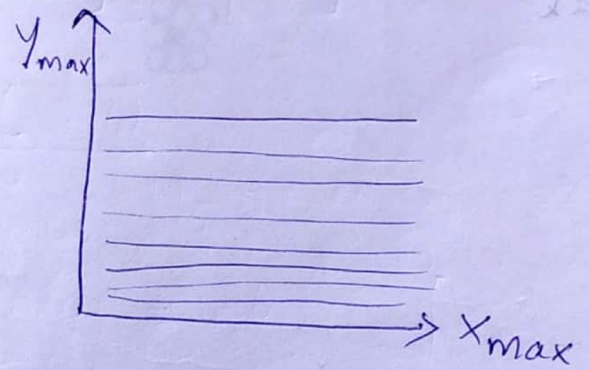
Y-shear

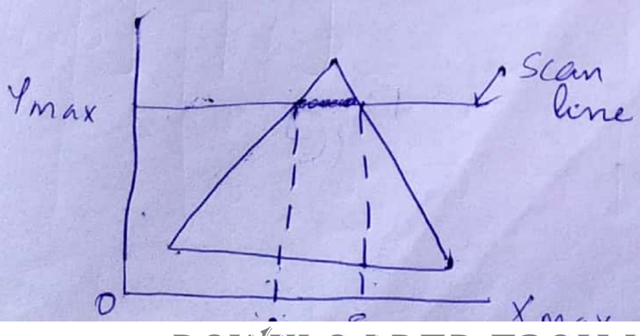
$x_{new} = 1$

$y_{new} = 0 + 2 \times 1 = 2$

$$\begin{bmatrix} x_{new} \\ y_{new} \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$$

Scan line polygon filling algorithm

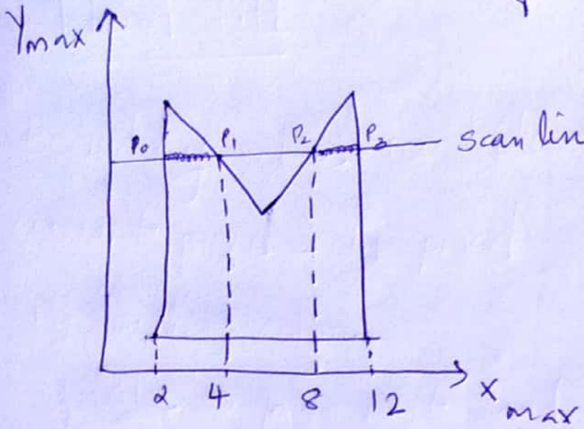




frame buffer

2	8

Case 1 : Even no. of intersection



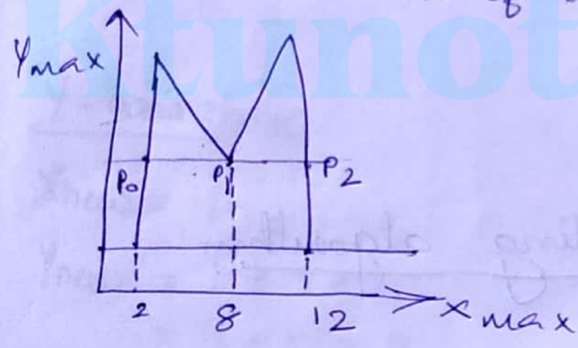
P_0	P_1	P_1	P_2	P_2	P_3

$(P_0, P_1) = (2,4)$

$(P_1, P_2) = (4,8)$

$(P_2, P_3) = (8,12)$

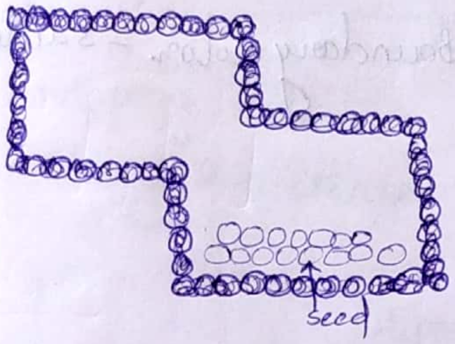
Case 2 : Odd no. of intersection



(P_0, P_1)

(P_1, P_2)

Flood Fill algorithm



multiple colour

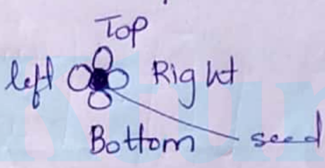
old colour = white

New colour = blue

Condition

current pixel = old colour

4 connected position



If same colour, then fill blue colour

8 connected position