UNIT II

Composite Transformation in 2-D graphics

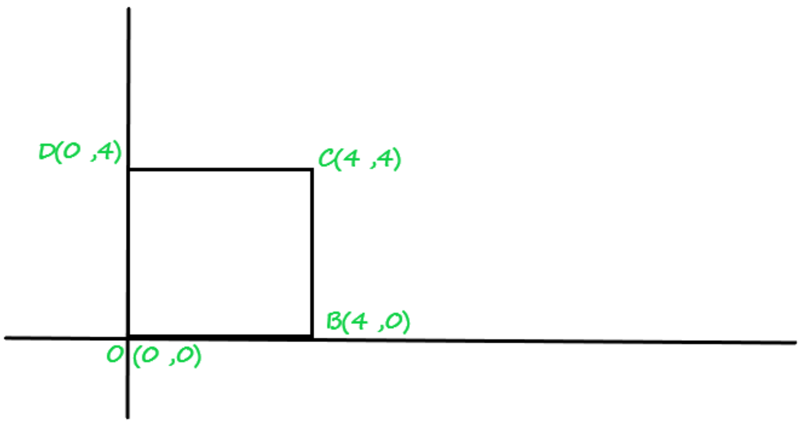
- 1. **Translation**
  2. **Scaling**
  3. **Rotation**
  4. **Reflection**
  5. **Shearing of a 2-D object**

Composite Transformation :
As the name suggests itself Composition, here we combine two or more transformations into one single transformation that is equivalent to the transformations that are performed one after one over a 2-D object.

Example :
Consider we have a 2-D object on which we first apply transformation **T1 (2-D matrix condition)** and then we apply transformation **T2(2-D matrix condition)** over the 2-D object and the object get transformed, the very equivalent effect over the 2-D object we can obtain by multiplying **T1 & T2 (2-D matrix conditions)** with each other and then applying the **T12 (resultant of T1 X T2)** with the coordinates of the 2-D image to get the transformed final image.

Problem :
Consider we have a square **O(0, 0), B(4, 0), C(4, 4), D(0, 4)** on which we first apply **T1(scaling transformation) given scaling factor is Sx=Sy=0.5** and then we apply **T2(rotation transformation in clockwise direction)** it by 90*(angle), in last we perform **T3(reflection transformation about origin).**

Ans : The square O, B, C, D looks like :



Square_given(Fig.1)

First, we perform scaling transformation over a 2-D object :

Representation of scaling condition :

[x′y′]=[Sx00Sx]∗[xy][x′y′]=[Sx00Sx]∗[xy]

For coordinate O(0, 0) :
O[xy]=[0.5000.5]∗[00]O[x’y’]=[00] O[xy]=[0.5000.5]∗[00]Ox’y’=[00]

For coordinate B(4, 0) :
B[xy]=[0.5000.5]∗[40]B[x’y’]=[20] B[xy]=[0.5000.5]∗[40]Bx’y’=[20]

For coordinate C(4, 4) :
C[xy]=[0.5000.5]∗[44]C[x’y’]=[22] C[xy]=[0.5000.5]∗[44]Cx’y’=[22]

For coordinate D(0, 4) :
D[xy]=[0.5000.5]∗[04]D[x’y’]=[02] D[xy]=[0.5000.5]∗[04]Dx’y’=[02]

2-D object after scaling :

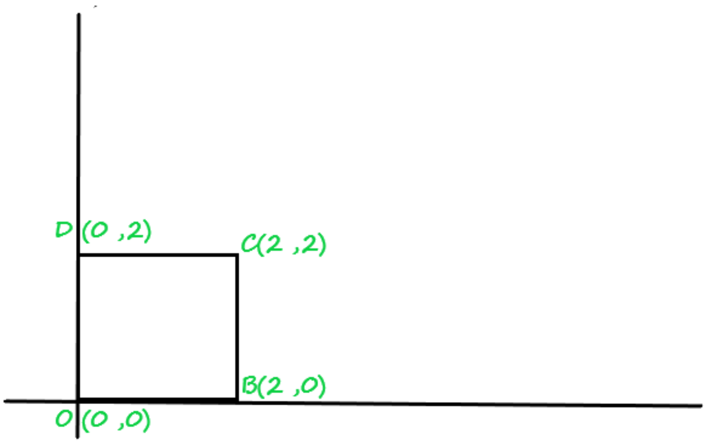


Fig.2

***Now, we’ll perform rotation transformation in clockwise-direction on Fig.2 by 90θ:**

The condition of rotation transformation of 2-D object about origin is :

[x′y′]=[cosθsinθ−sinθcosθ]∗[xy]Cos90=0sin90=1[x′y′]=[cosθ−sinθsinθcosθ]∗[xy]Cos90=0sin90=1

For coordinate O(0, 0) :
O[x’y’]=[01−10]∗[00]O[x’y’]=[00] O[x’y’]=[0−110]∗[00]Ox’y’=[00]

For coordinate B(2, 0) :
B[x’y’]=[01−10]∗[20]B[x’y’]=[0−2] B[x’y’]=[0−110]∗[20]Bx’y’=[0−2]

For coordinate C(2, 2) :
C[x’y’]=[01−10]∗[22]C[x’y’]=[2−2] *C*[*x*’*y*’]=[0−110]∗[22]*Cx*’*y*’=[2−2]

For coordinate D(0, 2) :
D[x’y’]=[01−10]∗[02]D[x’y’]=[20] *D*[*x*’*y*’]=[0−110]∗[02]*Dx*’*y*’=[20]

2-D object after rotating about origin by 90* angle :

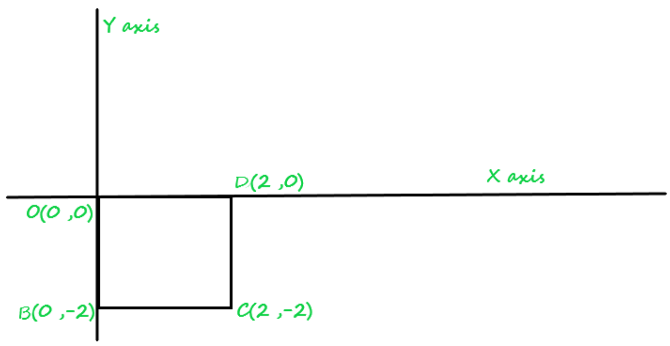


Fig.3

***Now, we’ll perform third last operation on Fig.3, by reflecting it about origin :**

The condition of reflecting an object about origin is

[x′y′]=[−100−1]∗[xy][*x*′*y*′]=[−100−1]∗[*xy*]

For coordinate O(0, 0) :
O[x’y’]=[−100−1]∗[00]O[x’y’]=[00] *O*[*x*’*y*’]=[−100−1]∗[00]*Ox*’*y*’=[00]

For coordinate B'(0, 0) :
B’[x’y’]=[0−1−10]∗[02]B’[x’y’]=[−20] *B*’[*x*’*y*’]=[0−1−10]∗[02]*B*’*x*’*y*’=[−20]

For coordinate C'(0, 0) :
C’[x’y’]=[−100−1]∗[2−2]C’[x’y’]=[−22] *C*’[*x*’*y*’]=[−100−1]∗[2−2]*C*’*x*’*y*’=[−22]

For coordinate D'(0, 0) :
D’[x’y’]=[−100−1]∗[0−2]D’[x’y’]=[02] *D*’[*x*’*y*’]=[−100−1]∗[0−2]*D*’*x*’*y*’=[02]

The final 2-D object after reflecting about origin, we get :

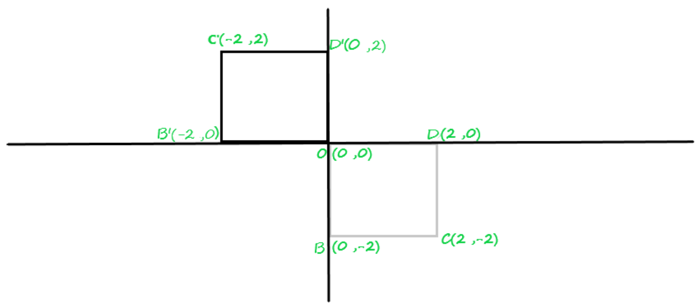


Fig.4

Note : The above finale result of **Fig.4**, that we get after applying all transformation one after one in a serial manner. We could also get the same result by combining all the transformation 2-D matrix conditions together and multiplying each other and get a resultant of multiplication(R). Then, applying that 2D-resultant matrix(R) at each coordinate of the given square(above). So, you will get the same result as you have in **Fig.4.**

Solution using Composite transformation :

*First we multiplied 2-D matrix conditions of **Scaling transformation** with **Rotation transformation :**

[R1]=[0.5000.5]∗[01−10][R1]=[00.5−0.50] [*R*1]=[0.5000.5]∗[0−110][*R*1]=[0−0.50.50]

*Now, we multiplied Resultant 2-D matrix(R1) with the third last given Reflecting condition of transformation(R2) to get Resultant(R) :

[R]=[00.5−0.50]∗[−100−1][R]=[0−0.50.50] [*R*]=[0−0.50.50]∗[−100−1][*R*]=[00.5−0.50]

Now, we'll applied the Resultant(R) of 2d-matrix at each coordinate of the given object (square) to get the final transformed or modified object.

First transformed coordinate O(0, 0) is :

O[x'y']=[0−0.50.50]∗[00]O[x'y']=[00] *O*[*x*'*y*']=[00.5−0.50]∗[00]*O**x*'*y*'=[00]

Second, transformed coordinate B'(4, 0) is :

B'[x'y']=[0−0.50.50]∗[40]B'[x'y']=[02] *B*'[*x*'*y*']=[00.5−0.50]∗[40]*B*'*x*'*y*'=[02]

Third transformed coordinate C'(4, 4) is :

C'[x'y']=[0−0.50.50]∗[44]C'[x'y']=[−22] *C*'[*x*'*y*']=[00.5−0.50]∗[44]*C*'*x*'*y*'=[−22]

Fourth transformed coordinate D'(0, 4) is :

D'[x'y']=[0−0.50.50]∗[04]D'[x'y']=[−20] *D*'[*x*'*y*']=[00.5−0.50]∗[04]*D*'*x*'*y*'=[−20]

The final result of the transformed object that you get would be same as above :