# Department of Computer Science and Engineering

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## UCS1712 - Graphics and Multimedia Lab

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### Exercise 5: 2D Transformations in C++ using OpenGL

#### Aim:

To apply the 2D transformations on objects and to render the final output along with the original object.

#### Code:

```
#ifndef LOPENGL_H
#define LOPENGL_H

#include <GL/freeglut.h>
#include <GL/gl.h>
#include <GL/glu.h>
#include <math.h>
#include <stdio.h>
#include<iostream>
#include<vector>
#include<ctime>
using namespace std;

#endif
```

```
#ifndef LUTIL_H
#define LUTIL_H

#include "Headers.h"

//Screen Constants
const int SCREEN_WIDTH = 640;
const int SCREEN_HEIGHT = 480;
const int SCREEN_FPS = 60;
const int POINT_SIZE=3;
vector<int> X_points;
vector<int> Y_points;

vector<pair<double, double>> transforms;

int edge_count;
int transformation;
double factor_x, factor_y;
double angle_radians;

bool initGL();

void update();

void render();

void y_axis();

void x_axis();

void setEdgeCount(int option);

vector<vector<double>> matrix_multiplication(double points[][3],
    double matrix[][3], int r1, int c1, int r2, int c2);

void drawPolygon();

void drawTranslatedPolygon(double x, double y);

void drawRotatedPolygon(double angle_radians, double x, double y);

void drawScaledPolygon(double x, double y, double xf, double yf);

void drawReflectedPolygon(double angle_radians, double intercept);

void drawShearedPolygon(double shx, double shy);

#endif
```

```
#include "Signatures.h"

bool initGL(){

    //Initialize Projection Matrix
    glMatrixMode( GL_PROJECTION );
    glLoadIdentity();
    gluOrtho2D(-640.0,640.0,-480.0,480.0);

```

```
10      //Initialize clear color
11      glClearColor( 0.f, 0.f, 0.f, 1.f );
12      glColor3f(0.0f, 0.0f, 0.0f);
13
14      glPointSize(POINT_SIZE);
15      glEnable(GL_POINT_SMOOTH);
16
17      //Check for error
18      GLenum error = glGetError();
19      if( error != GL_NO_ERROR )
20      {
21          printf( "Error initializing OpenGL! %s\n", gluErrorString(
        error ) );
22          return false;
23      }
24
25      return true;
26  }
27
28  void update(){
29
30  }
31
32  void render(){
33      glClear(GL_COLOR_BUFFER_BIT);
34      glColor3f(1.0, 1.0, 1.0);
35      drawPolygon();
36      glFlush();
37
38      while(true){
39          glClear(GL_COLOR_BUFFER_BIT);
40          glColor3f(1.0, 1.0, 1.0);
41
42          cout<<"Choose transformation: "<<endl;
43          cout<<"1 for Translation"<<endl<<"2 for Rotation"<<endl;
44          cout<<"3 for Scaling"<<endl<<"4 for Reflection"<<endl;
45          cout<<"5 for shearing"<<endl<<"0 to Exit"<<endl;
46          cout<<"Enter your choice: ";cin>>transformation;
47
48          cout<<"transformation: "<<transformation<<endl;
49          if(!transformation){
50              return;
51          }
52
53          if(transformation == 1){
54              cout<<"Enter the translation factor for X and Y: ";
55              cin>>factor_x >> factor_y;
56              drawPolygon();
57              drawTranslatedPolygon(factor_x,factor_y);
58          }
59          else if(transformation == 2){
60              double angle;
61              cout<<"Enter the rotation angle: ";
62              cin>>angle;
63              double x,y;
64              cout<<"Enter point about which to be rotated: ";
65              cin>>x>>y;
```

```
66              angle_radians = angle * 3.1416 / 180;
67              drawPolygon();
68              drawRotatedPolygon(angle_radians, x, y);
69          }
70          else if(transformation == 3){
71              cout<<"Enter the scaling factor for X and Y: ";
72              cin>>factor_x >> factor_y;
73              double x,y;
74              cout<<"Enter point about which to be scaled: ";
75              cin>>x>>y;
76              drawPolygon();
77              drawScaledPolygon(factor_x,factor_y, x, y);
78          }
79          else if(transformation == 4){
80              double angle;
81              cout<<"Enter the angle with X-axis and Y-intercept of
    the mirror: ";
82              cin>>angle >> factor_y;
83              angle_radians = angle * 3.1416/180;
84              drawPolygon();
85              drawReflectedPolygon(angle_radians,factor_y);
86          }
87          else if(transformation == 5){
88              cout<<"Enter the shearing factor for X and Y: ";
89              cin>>factor_x >> factor_y;
90              drawPolygon();
91              drawShearedPolygon(factor_x, factor_y);
92          }
93          else if(transformation){
94              cout<<"Invalid option"<<endl;
95          }
96          else;
97      }
98
99      glFlush();
100 }
101
102 void y_axis(){
103     glColor3f(1.0,1.0,1.0);
104     glBegin(GL_LINES);
105         glVertex2d(0, -480.0);
106         glVertex2d(0, 480.0);
107     glEnd();
108     // glFlush();
109 }
110
111 void x_axis(){
112     glColor3f(1.0,1.0,1.0);
113     glBegin(GL_LINES);
114         glVertex2d(-640.0, 0);
115         glVertex2d(640.0, 0);
116     glEnd();
117     // glFlush();
118 }
119
120 void setEdgeCount(int option){
121     if(option == 0){
```

```
122         cout<<"Invalid"<<endl;
123     }
124     else if(option == 1 || option == 2){
125         edge_count = 2;
126     }
127     else{
128         edge_count = option;
129     }
130 }
131 
132 vector<vector<double>> matrix_multiplication(double points[][3],
        double matrix[][3], int r1, int c1, int r2, int c2){
133 
134     vector<vector<double>> ans(3);
135 
136     for(int i=0;i<r1;i++){
137         for(int j=0;j<c2;j++){
138             ans[i].push_back(0);
139         }
140     }
141     for(int i=0;i<r1;i++){
142         for(int j=0;j<c2;j++){
143             for(int k=0;k<r2;k++){
144                 ans[i][j] += (points[i][k] * matrix[k][j]);
145             }
146         }
147     }
148     return ans;
149 }
150 
151 double round(double d){
152     return floor(d + 0.5);
153 }
154 
155 void drawPolygon(){
156     y_axis();
157     x_axis();
158     glColor3f(1.0,1.0,1.0);
159     if(edge_count==2)
160         glBegin(GL_LINES);
161     else
162         glBegin(GL_POLYGON);
163 
164     for (int i = 0; i < edge_count; i++){
165         glVertex2d(X_points[i], Y_points[i]);
166     }
167     glEnd();
168     glFlush();
169 }
170 
171 void drawTranslatedPolygon(double x, double y){
172     double translate_matrix[2][1] = {{x}, {y}};
173     for(int i=0;i<edge_count;i++){
174         double new_x = X_points[i] + translate_matrix[0][0];
175         double new_y = Y_points[i] + translate_matrix[1][0];
176         transforms.push_back(pair<double, double>(new_x, new_y));
177     }
```

```
178     glFlush();
179     glColor3f(0.0, 1.0, 0.0);
180     if (edge_count == 2)
181         glBegin(GL_LINES);
182     else
183         glBegin(GL_POLYGON);
184 
185     for(pair<double, double> p: transforms){
186         glVertex2d(p.first, p.second);
187     }
188     glEnd();
189     glFlush();
190     transforms.clear();
191 }
192 
193 void drawRotatedPolygon(double angle_radians, double x, double y){
194     double rotate_matrix[2][3] = {{cos(angle_radians), sin(
    angle_radians)}, {-sin(angle_radians), cos(angle_radians)}};
195     double adjust_matrix[1][2] = {-x, -y};
196     double reset_matrix[1][2] = {x, y};
197     for(int i=0;i<edge_count;i++){
198         double points[1][3] = {{X_points[i]+adjust_matrix[0][0],
    Y_points[i]+adjust_matrix[0][1]}};
199         vector<vector<double>> ans = matrix_multiplication(points,
    rotate_matrix, 1, 2, 2, 2);
200         transforms.push_back(pair<double, double>(ans[0][0]+
    reset_matrix[0][0], ans[0][1]+reset_matrix[0][1]));
201     }
202 
203     glFlush();
204     glColor3f(0.0, 1.0, 0.0);
205     if (edge_count == 2)
206         glBegin(GL_LINES);
207     else
208         glBegin(GL_POLYGON);
209 
210     for(pair<double, double> p: transforms){
211         glVertex2d(round(p.first), round(p.second));
212     }
213     glEnd();
214     glFlush();
215     transforms.clear();
216 }
217 
218 void drawScaledPolygon(double x, double y, double xf, double yf){
219     double scale_matrix[2][3] = {{x, 0}, {0, y}};
220     for(int i=0;i<edge_count;i++){
221         double points[1][3] = {{X_points[i], Y_points[i]}};
222         vector<vector<double>> ans = matrix_multiplication(points,
    scale_matrix, 1, 2, 2, 2);
223         double x_impact = xf*(1-x);
224         double y_impact = yf*(1-y);
225         transforms.push_back(pair<double, double>(ans[0][0]+
    x_impact, ans[0][1]+y_impact));
226     }
227 
228     glFlush();
```

```
    glColor3f(0.0, 1.0, 0.0);
    if (edge_count == 2)
        glBegin(GL_LINES);
    else
        glBegin(GL_POLYGON);

    for(pair<double, double> p: transforms){
        glVertex2d(round(p.first), round(p.second));
    }
    glEnd();
    glFlush();
    transforms.clear();
}

void drawReflectedPolygon(double angle_radians, double intercept){
    double reflect_matrix[3][3] = {{cos(2*angle_radians), sin(2*angle_radians), intercept*sin(2*angle_radians)},
                                   {sin(2*angle_radians), -cos(2*angle_radians), -intercept*cos(2*angle_radians)+1},
                                   {0, 0, 1}};
    for(int i=0;i<edge_count;i++){
        double points[1][3] = {{X_points[i], Y_points[i], 0}};
        vector<vector<double>> ans = matrix_multiplication(points, reflect_matrix, 1, 3, 3, 3);
        transforms.push_back(pair<double, double>(ans[0][0], ans[0][1]));
    }

    glFlush();
    glColor3f(0.0, 1.0, 0.0);
    if (edge_count == 2)
        glBegin(GL_LINES);
    else
        glBegin(GL_POLYGON);

    for(pair<double, double> p: transforms){
        glVertex2d(round(p.first), round(p.second));
    }
    glEnd();
    glFlush();
    transforms.clear();
}

void drawShearedPolygon(double shx, double shy){
    double reflect_matrix[3][3] = {{1, shy, 0},
                                   {shx, 1, 0},
                                   {0, 0, 1}};
    for(int i=0;i<edge_count;i++){
        double points[1][3] = {{X_points[i], Y_points[i], 0}};
        vector<vector<double>> ans = matrix_multiplication(points, reflect_matrix, 1, 3, 3, 3);
        transforms.push_back(pair<double, double>(ans[0][0], ans[0][1]));
    }

    glFlush();
    glColor3f(0.0, 1.0, 0.0);
```

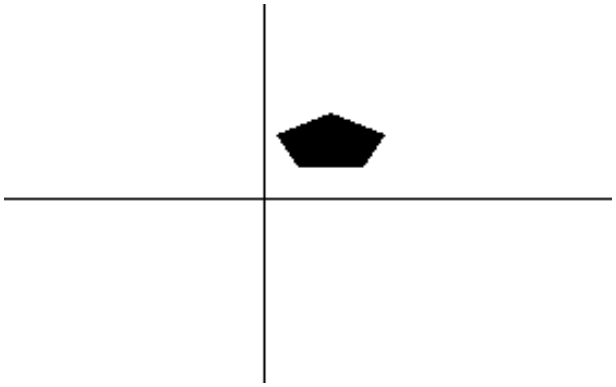
```
    if (edge_count == 2)
        glBegin(GL_LINES);
    else
        glBegin(GL_POLYGON);

    for(pair<double, double> p: transforms){
        glVertex2d(round(p.first), round(p.second));
    }
    glEnd();
    glFlush();
    transforms.clear();
}
```

```
#include "Helpers.h"

void runMainLoop(int val);

int main( int argc, char* args[] ){

    glutInit( &argc, args );

    glutInitContextVersion( 2, 1 );

    glutInitDisplayMode( GLUT_SINGLE|GLUT_RGB );
    glutInitWindowSize( SCREEN_WIDTH, SCREEN_HEIGHT );
    glutCreateWindow( "OpenGL" );

    int option=0;
    cout<<"Choose number of edges: (1 for line, 3 and upwards for
    polygon): ";
    cin>>option;

    setEdgeCount(option);
    cout<<"Enter vertices: "<<endl;
    for(int i=0;i<edge_count;i++){
        cout<<"Vertex "<<i+1<<" (x,y): ";
        int x,y;
        cin>>x>>y;
        X_points.push_back(x);
        Y_points.push_back(y);

    }

    drawPolygon();
    cout<<"Number of edges: "<<edge_count<<endl;

    if( !initGL() )
    {
        printf( "Unable to initialize graphics library!\n" );
        return 1;
    }


    glutDisplayFunc( render );

    glutTimerFunc( 1000 / SCREEN_FPS, runMainLoop, 0 );

    glutMainLoop();
```

```
45
46      return 0;
47  }
48
49  void runMainLoop( int val ){
50      update();
51      render();
52
53      glutTimerFunc( 1000 / SCREEN_FPS, runMainLoop, val );
54  }
```

## Output:

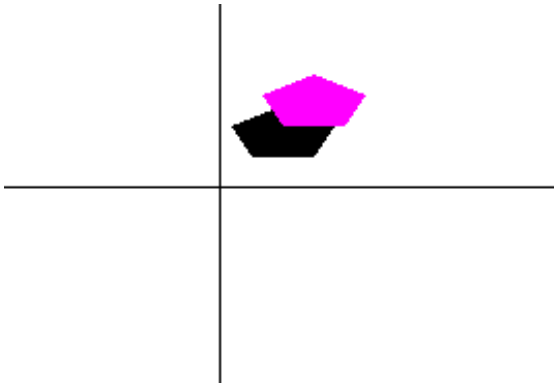
**Original Image:**
Choose number of edges: (1 for line, 3 and upwards for polygon): 5
Enter vertices:
Vertex 1 (x,y): 30 30
Vertex 2 (x,y): 10 60
Vertex 3 (x,y): 60 80
Vertex 4 (x,y): 110 60
Vertex 5 (x,y): 90 30
Number of edges: 5



**Translation:**

Choose transformation:
1 for Translation
2 for Rotation
3 for Scaling
4 for Reflection
5 for shearing
0 to Exit
Enter your choice: 1

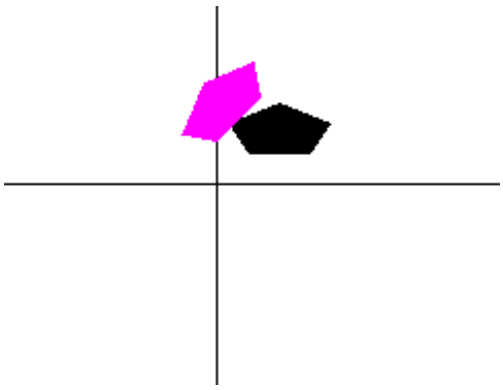
Enter the translation factor for X and Y: 30 30



## Rotation:

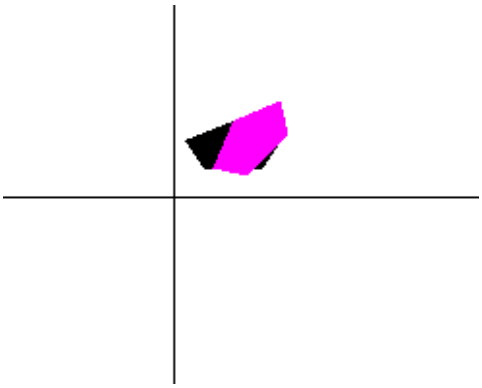
**About origin:**

Enter the rotation angle: 45
Enter point about which to be rotated: 0 0



**About fixed point:**

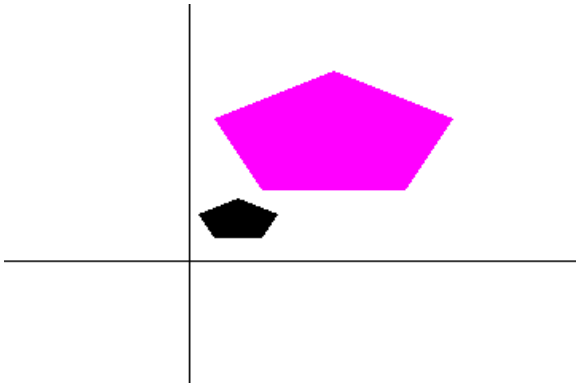
Enter the rotation angle: 45
Enter point about which to be rotated: 60 80



## Scaling:

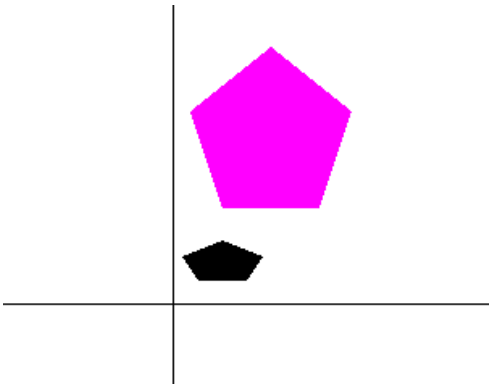
**About origin - Uniform:**

Enter the scaling factor for X and Y: 3 3
Enter point about which to be scaled: 0 0



**About origin - Differential:**

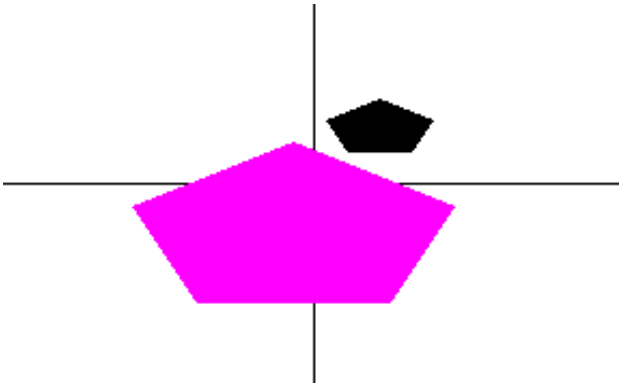
Enter the scaling factor for X and Y: 2 4
Enter point about which to be scaled: 0 0



**About fixed point:**

Enter the scaling factor for X and Y: 3 3

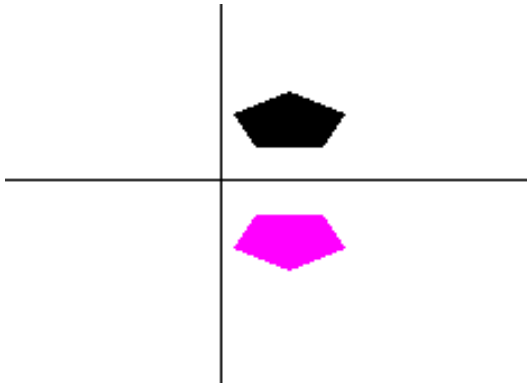
Enter point about which to be scaled: 100 100



## Reflection:

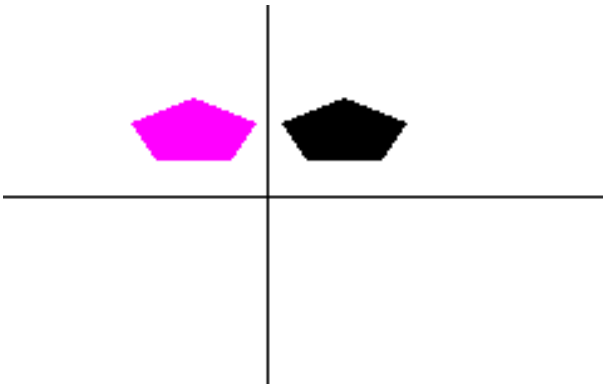
**With respect to X-axis:**

Enter the angle with X-axis and Y-intercept of the mirror: 0 0

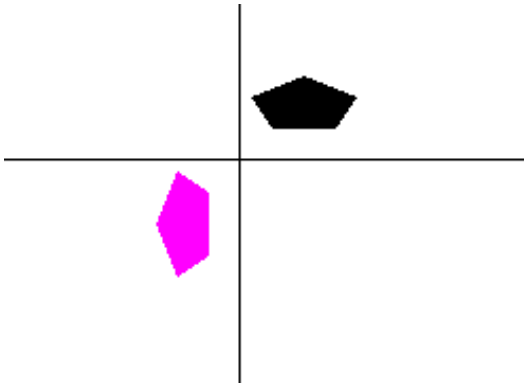


**With respect to Y-axis:**

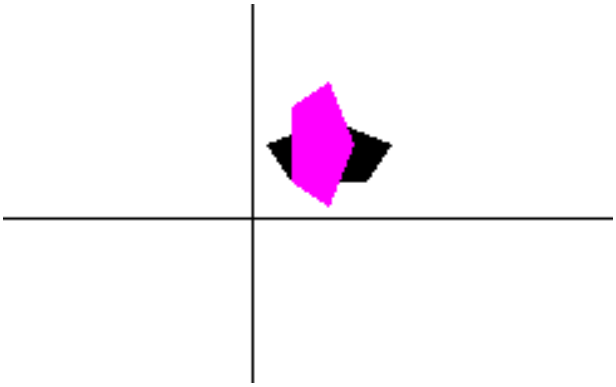
Enter the angle with X-axis and Y-intercept of the mirror: 90 0



**With respect to origin:**
Enter the angle with X-axis and Y-intercept of the mirror: 135 0



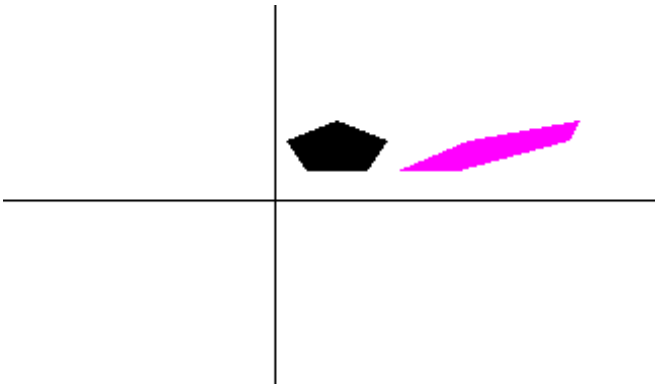
**With respect to line x=y:**
Enter the angle with X-axis and Y-intercept of the mirror: 45 0



## Shearing:

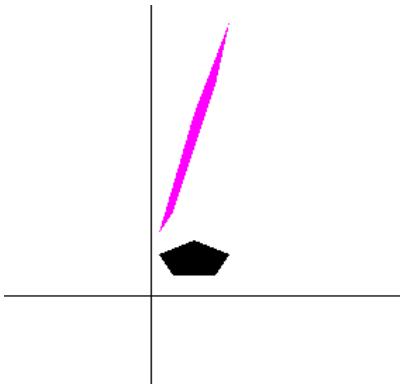
**X-direction:**

Enter the shearing factor for X and Y: 3 0



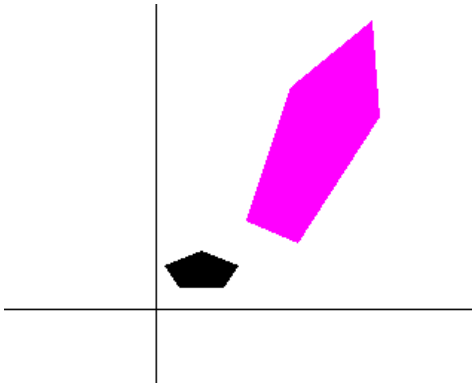
**Y-direction:**

Enter the shearing factor for X and Y: 0 3



**Both X and Y directions:**

Enter the shearing factor for X and Y: 3 3



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