SSN COLLEGE OF ENGINEERING, KALAVAKKAM DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
UCS1712 - GRAPHICS AND MULTIMEDIA LAB

Assignment- 6 - 2D Composite Transformations and Windowing in C++ using OpenGL

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Aim:

To compute the composite transformation matrix for any 2 transformations input by the user and apply it on the object.

1) Translation
2) Rotation
3) Scaling
4) Reflection
5) Shearing

Display the original and the transformed object.

Algorithm:

1. Get points of the object as input.
2. Draw the object.
3. Transform each vertex of the object.
4. Draw the object with the transformed vertices.

Code:

```
#define GL_SILENCE_DEPRECATION
#include<GLUT/glut.h>
#include<stdio.h>
#include<iostream>
#include<math.h> using
namespace std; float
toRad(float xDeg) { return
xDeg * 3.14159 / 180; }
void myInit() {
glClearColor(1, 1, 1, 1);
//
```

```
violet glColor3f(0.0f, 0.0f, 0.5f); //dark blue
//glPointSize(10);
glMatrixMode(GL_PROJECTION);
glLineWidth(2);


glLoadIdentity(); gluOrtho2D(0.0,
640.0, 0.0, 480.0);
} void displayPoint(float x, float y) {
glBegin(GL_POINTS); glVertex2d(x + 320, y
+ 240); glEnd(); } void
displayHomogeneousPoint(float* h) { float x
= *(h + 0); float y = *(h + 1); glColor4f(0, 1,
0.4, 1); //green displayPoint(x, y); } void
displayLine(int x1, int y1, int x2, int y2) {
glBegin(GL_LINES); glVertex2d(x1 + 320, y1
+ 240); glVertex2d(x2 + 320, y2 +
240); glEnd(); } void displayTriangle(int x1, int y1, int x2, int
y2, int x3, int y3) { glBegin(GL_TRIANGLES); glVertex2d(x1
+ 320, y1 + 240); glVertex2d(x2 + 320, y2 + 240);
glVertex2d(x3 + 320, y3 +
240); glEnd(); } void displayTransformedTriangle(float* p1,
float* p2, float* p3) { float x1 = *(p1 + 0); float y1 = *(p1 + 1);
float x2 = *(p2 + 0);
float y2 = *(p2 + 1);
float x3 =
*(p3 + 0); float y3 =
*(p3 + 1);
glColor4f(0, 1, 0.4, 1); //green
displayTriangle(x1, y1, x2, y2, x3, y3);
} void drawPlane() {
glClear(GL_COLOR_BUFFER_BIT);
glColor4f(0, 0, 0, 1); //yellow
displayLine(-320, 0, 320, 0); //x-axis
displayLine(0, -240, 0, 240); //y-axis
glFlush();


} void printMenu() { cout << "1 - Translation"
<< endl; cout << "2 - Rotation about origin"
<< endl; cout << "3 - Rotation wrt fixed point"
<< endl; cout << "4 - Scaling wrt origin" <<
```

```
endl; cout << "5 - Scaling wrt fixed point" <<
endl; cout << "6 - Reflection wrt x-axis" <<
endl; cout << "7 - Reflection wrt y-axis" <<
endl; cout << "8 - Reflection wrt origin" <<
endl; cout << "9 - Reflection wrt line x=y" <<
endl; cout << "10 - Shearing along x-dir" <<
endl; cout << "11 - Shearing along y-dir" <<
endl; cout << "0 - All done" << endl;
} void printMatrix(float* arr, int m, int
n)
{
int i, j;
for (i = 0; i < m; i++) { for (j =
0; j < n; j++) cout << *((arr +
i*n) + j) << " "; cout << endl; }
}
float* mulMatrix(float* a, int m1, int n1, float* b, int m2, int n2) {
if (n1 != m2) { cout << "Multiplication Input Error" << endl;
return NULL; } float* res = new float[m1 * n2]; for (int i = 0; i <
m1; i++) { for (int j = 0; j < n2; j++) { *((res + i*n2) + j) = 0; for
(int k = 0; k < n1; k++) {
*((res + i*n2) + j) += *((a + i*n1) + k) * *((b + k*n2) + j);
}
} } return res; } void
printPoint(float* P) {
printMatrix(P, 3, 1);
}


void printMatrix3(float* M) {
printMatrix(M, 3, 3);
} float* transformPoint(float* m, float* p)
{ return mulMatrix(m, 3, 3, p, 3, 1);
} float* mulTransforms(float* m1, float*
m2)
{ return mulMatrix(m1, 3, 3, m2, 3, 3);
} float* getTransformationMatrix()
{
cout << "COMPOSITE TRANSFORMATION" << endl;
float* compositeMatrix = new float[3 * 3]; for (int i = 0;
```

```
i < 3; i++) { for (int j = 0; j < 3; j++) {
compositeMatrix[i*3 + j] = (i == j) ? 1 :
0;
} }
printMenu();
int ch;
do {
cout << "\nChoose required transformation: ";
cin >> ch; switch (ch) { case 1: { cout <<
"TRANSLATION" << endl;
float tx, ty; cout << "Enter
translation values: "; cin >> tx >>
ty; float T[3][3] = { {1, 0, tx},
{0, 1, ty},
{0, 0, 1}
}; float* temp = mulTransforms((float*)T,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; } case 2: { cout
<< "ROTATION ABOUT ORIGIN" << endl;
float angle; cout << "Enter
rotation angle: "; cin >> angle;


float theta = toRad(angle);
float c = cos(theta); float s
= sin(theta); float R[3][3]
= { {c, -s, 0},
{s, c, 0},
{0, 0, 1}
}; float* temp = mulTransforms((float*)R,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break;
} case 3: { cout << "ROTATION WRT FIXED
POINT" << endl; float angle; cout << "Enter rotation
angle: "; cin >> angle; float theta = toRad(angle);
float c = cos(theta); float s = sin(theta); float xr, yr;
cout << "Enter fixed point coords: "; cin >> xr >> yr;
float R[3][3] = { {c, -s, (xr * (1-c)) + (yr * s)},
{s, c, (yr * (1-c)) - (xr * s)},
{0, 0, 1}
```

```
}; float* temp = mulTransforms((float*)R,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; } case 4: {
cout << "SCALING WRT ORIGIN" << endl;
float sx, sy; cout << "Enter scaling
factor values: "; cin >> sx >> sy; float
S[3][3] = { {sx, 0, 0},
{0, sy, 0},
{0, 0, 1}


}; float* temp = mulTransforms((float*)S,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; } case 5: { cout <<
"SCALING WRT FIXED POINT" << endl;
float sx, sy; cout << "Enter scaling
factor values: "; cin >> sx >> sy;
float xf, yf; cout << "Enter fixed
point coords: "; cin >> xf >> yf;
float S[3][3] = { {sx, 0, xf * (1-sx)},
{0, sy, yf * (1-sy)},
{0, 0, 1}
}; float* temp = mulTransforms((float*)S,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; } case 6: { cout <<
"REFLECTION WRT X-AXIS" << endl; float RF[3][3] =
{ {1, 0, 0},
{0, -1, 0},
{0, 0, 1}
}; float* temp = mulTransforms((float*)RF,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; } case 7: { cout
<< "REFLECTION WRT Y-AXIS" << endl;
float RF[3][3] = { {-1, 0, 0},
{0, 1, 0},
{0, 0, 1}
};
```

```
float* temp = mulTransforms((float*)RF,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; }
case 8: { cout << "REFLECTION WRT
ORIGIN" << endl; float RF[3][3] = { {-1, 0, 0},
{0, -1, 0},
{0, 0, 1}
}; float* temp = mulTransforms((float*)RF,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; } case 9: { cout <<
"REFLECTION WRT LINE X=Y" << endl; float
RF[3][3] = { {0, 1, 0},
{1, 0, 0},
{0, 0, 1}
}; float* temp = mulTransforms((float*)RF,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break;
} case 10: { cout << "SHEARING ALONG X-
DIR" << endl;
float shx, yref = 0; cout <<
"Enter shear value: "; cin >>
shx; cout << "Enter yref
value: "; cin >> yref; float
SH[3][3] = { {1, shx,-shx *
yref},
{0, 1, 0},
{0, 0, 1}
}; float* temp = mulTransforms((float*)SH,
compositeMatrix); delete[] compositeMatrix;


compositeMatrix = temp;
break; } case 11: { cout << "SHEARING
ALONG Y-DIR" << endl;
float shy, xref = 0; cout <<
"Enter shear value: "; cin >>
shy; cout << "Enter yref
value: "; cin >> xref; float
SH[3][3] = { {1, 0, 0},
{shy, 1, -shy * xref},
{0, 0, 1}
```

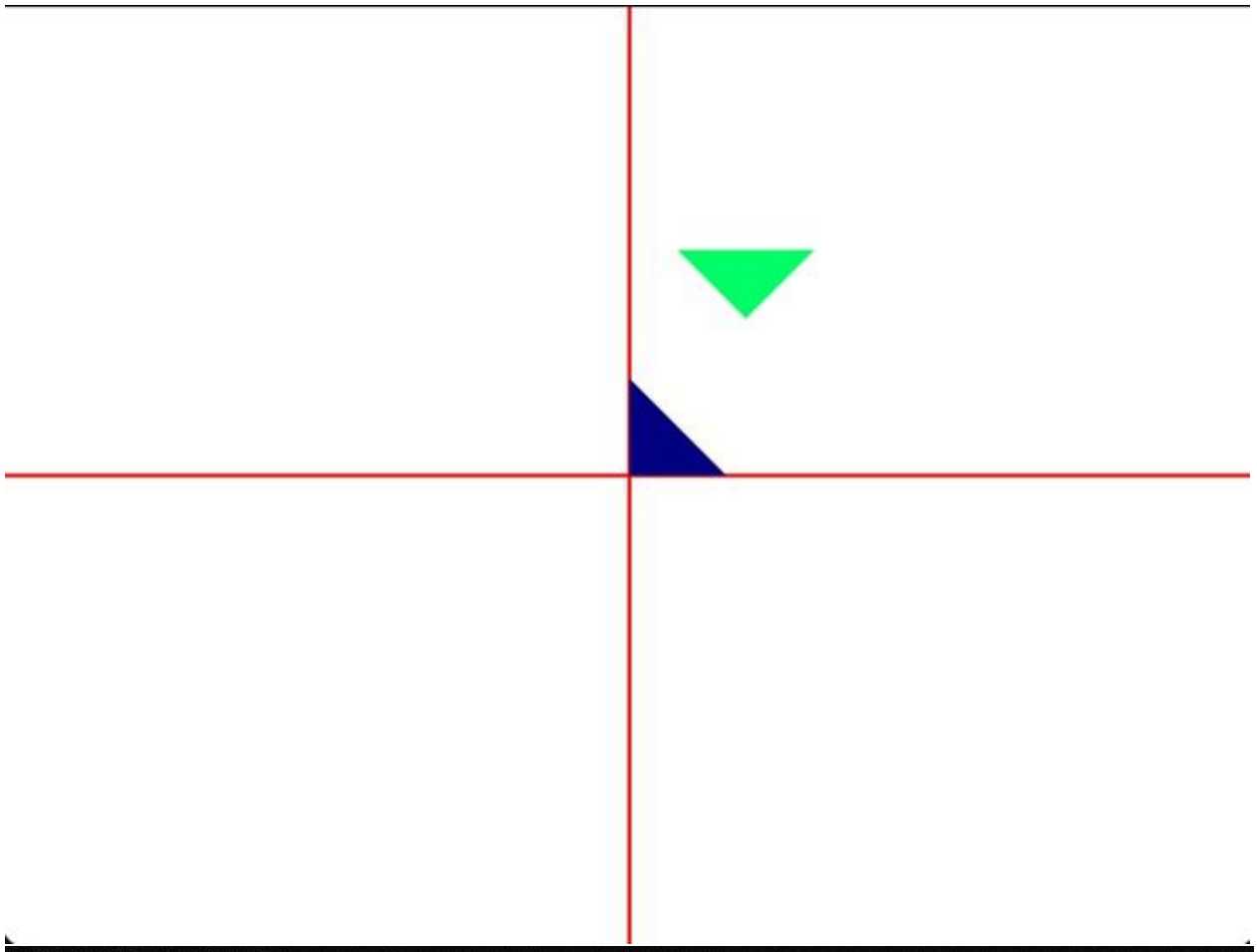
```
}; float* temp = mulTransforms((float*)SH,
compositeMatrix); delete[] compositeMatrix;
compositeMatrix = temp; break; } case 0: {
cout << "ALL DONE" << endl;
}
default:
break;
}
} while (ch != 0); return
compositeMatrix;
} void
plotTransform()
{
cout << "TRANSFORMATION OF A TRIANGLE" << endl;
//Point P1 float x1, y1; cout << "Enter point P1 coords:
"; cin >> x1 >> y1; float* P1 = new float[3]{ {x1},
{y1}, {1} }; cout << "Homogeneous representation of
P1: " << endl; printPoint(P1); cout << endl; //Point P2
float x2, y2; cout << "Enter point P2 coords: ";
cin >> x2 >> y2;


float* P2 = new float[3] { {x2}, { y2 }, { 1 } }; cout <<
"Homogeneous representation of P2: " << endl;
printPoint(P2); cout << endl; //Point P3 float x3, y3;
cout << "Enter point P3 coords: "; cin >> x3 >> y3;
float* P3 = new float[3] { {x3}, { y3 }, { 1 } }; cout <<
"Homogeneous representation of P3: " << endl;
printPoint(P3); cout << endl;
//plot triangle displayTriangle(x1, y1,
x2, y2, x3, y3); float* M =
getTransformationMatrix(); if (M !=
NULL) {
cout << "\nTransformation Matrix: " <<
endl; printMatrix3(M); cout << "\nP1': "
<< endl; float* Q1 = transformPoint(M,
P1); printPoint(Q1); cout << "\nP2': " <<
endl; float* Q2 = transformPoint(M, P2);
printPoint(Q2); cout << "\nP3': " << endl;
float* Q3 = transformPoint(M, P3);
printPoint(Q3);
```

```
displayTransformedTriangle(Q1, Q2, Q3);
delete[] Q1; delete[] Q2; delete[] Q3; }
delete[] M; delete[] P1; delete[] P2;
delete[] P3; } void plotChart() {
glClear(GL_COLOR_BUFFER_BIT);
drawPlane(); plotTransform(); glFlush(); }


int main(int argc, char* argv[]) {
glutInit(&argc, argv);
glutInitDisplayMode(GLUT_SINGLE | GLUT_RGBA);
glutInitWindowSize(640, 480);
glutCreateWindow("Transformations");
glutDisplayFunc(plotChart); myInit(); glutMainLoop();
return 1; }
```

Output:

```
TRANSFORMATION OF A TRIANGLE
Enter point P1 coords: 0 0
Homogeneous representation of P1:
0
0
1

Enter point P2 coords: 50 0
Homogeneous representation of P2:
50
0
1

Enter point P3 coords: 0 50
Homogeneous representation of P3:
0
50
1

COMPOSITE TRANSFORMATION
1 - Translation
2 - Rotation about origin
3 - Rotation wrt fixed point
4 - Scaling wrt origin
5 - Scaling wrt fixed point
6 - Reflection wrt x-axis
7 - Reflection wrt y-axis
8 - Reflection wrt origin
9 - Reflection wrt line x=y
10 - Shearing along x-dir
11 - Shearing along y-dir
0 - All done
```

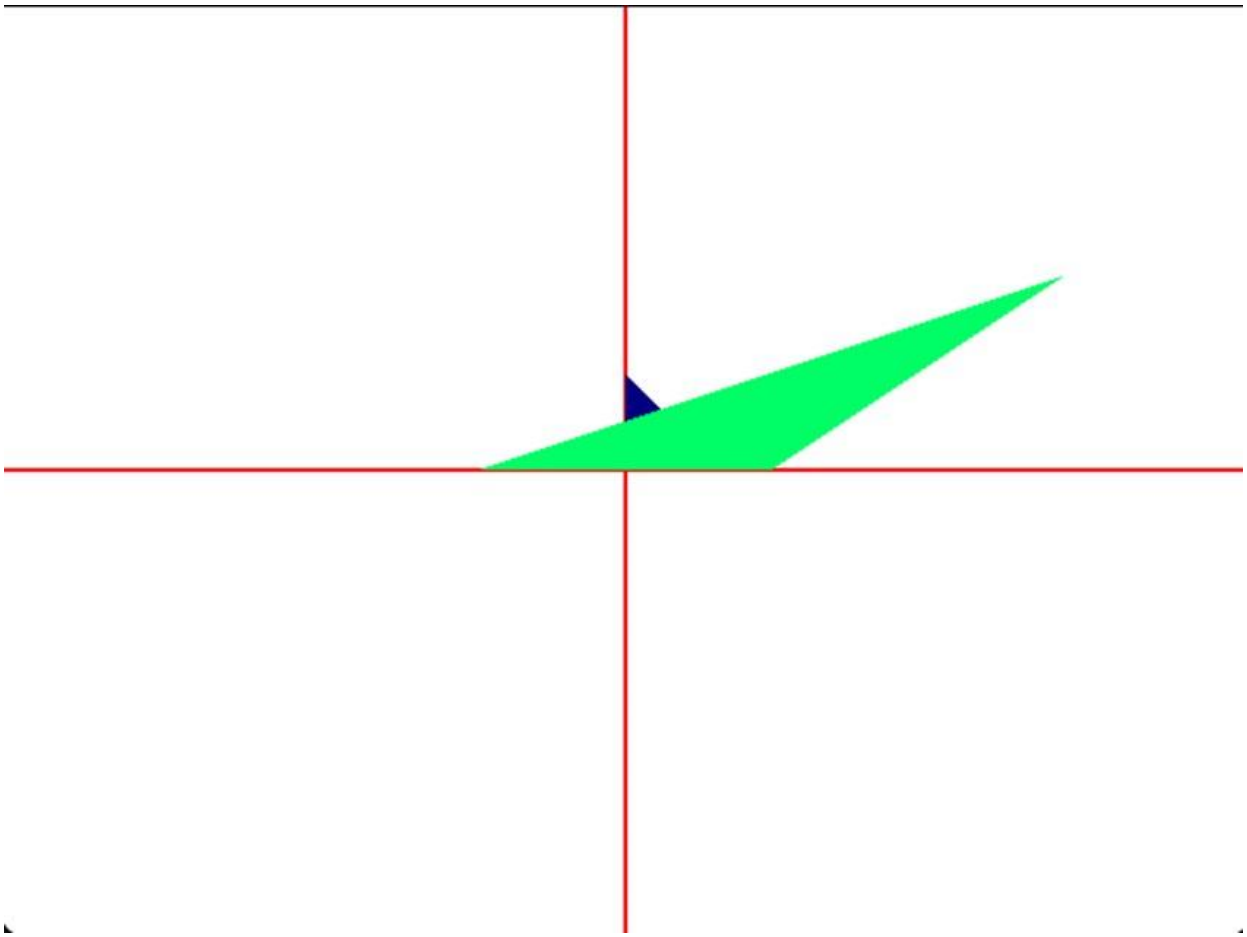
```
Choose required transformation: 1
TRANSLATION
Enter translation values: 60 80

Choose required transformation: 3
ROTATION WRT FIXED POINT
Enter rotation angle: 45
Enter fixed point coords: 60 80

Choose required transformation: 0
ALL DONE

Transformation Matrix:
0.707107 -0.707106 60
0.707106 0.707107 80
0 0 1

P1':
60
80
1

P2':
95.3554
115.355
1

P3':
24.6447
115.355
1
```



```
TRANSFORMATION OF A TRIANGLE
Enter point P1 coords: 0 0
Homogeneous representation of P1:
0
0
1

Enter point P2 coords: 0 50
Homogeneous representation of P2:
0
50
1

Enter point P3 coords: 50 0
Homogeneous representation of P3:
50
0
1

COMPOSITE TRANSFORMATION
1 - Translation
2 - Rotation about origin
3 - Rotation wrt fixed point
4 - Scaling wrt origin
5 - Scaling wrt fixed point
6 - Reflection wrt x-axis
7 - Reflection wrt y-axis
8 - Reflection wrt origin
9 - Reflection wrt line x=y
10 - Shearing along x-dir
11 - Shearing along y-dir
0 - All done
```

```
Choose required transformation: 4
SCALING WRT ORIGIN
Enter scaling factor values: 3 2

Choose required transformation: 8
REFLECTION WRT ORIGIN

Choose required transformation: 6
REFLECTION WRT X-AXIS

Choose required transformation: 10
SHEARING ALONG X-DIR
Enter shear value: 1.5
Enter yref value: -50

Choose required transformation: 0
ALL DONE

Transformation Matrix:
-3 3 75
0 2 0
0 0 1

P1':
75
0
1

P2':
225
100
1

P3':
-75
0
1
```

```
Choose required transformation: 0
ALL DONE

Transformation Matrix:
-3 3 75
0 2 0
0 0 1

P1':
75
0
1

P2':
225
100
1

P3':
-75
0
1
```



Aim:

Create a window with any 2D object and a different sized viewport. Apply window to viewport transformation on the object. Display both window and viewport.

Algorithm:

1. Store the window dimensions and the viewport dimensions.
2. Get points of the object as input and draw it on the window.
3. Apply window to viewport transformation on the object as:
    a. Sx = (xvmax - xvmin) / (xwmax - xwmin)
    b. xv = xvmin + (xw - xwmin) * Sx
    c. Similarly, for the y-coordinates.
4. Draw the object on the viewport.

Code:

```
#define GL_SILENCE_DEPRECATION
#include<GLUT/glut.h>
#include<stdio.h>
#include<iostream> #include<math.h> using namespace std;
float xvmax = 640, yvmax = 480, xwmax = 1280, ywmax = 960;
void myInit_window() { glClearColor(1,1,1,1.0);
glColor3f(0.0f,0.0f,0.0f); glPointSize(3); glLineWidth(3);
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
gluOrtho2D(0.0,1280.0,0.0,960.0);
} void myInit_viewport() {
glClearColor(1,1,1,1.0);
glColor3f(0.0f,0.0f,0.0f);
glPointSize(3); glLineWidth(3);
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
gluOrtho2D(0.0,640.0,0.0,480.0);
}
void displayaxes_window(){
glBegin(GL_LINES);
glColor4f(0,0.5,0,1); //y - axis
glVertex2d(640,0);
glVertex2d(640,960); //x - axis
glVertex2d(0,480);
glVertex2d(1280,480); glEnd();
```

```
} void
displayaxes_viewport(){
glBegin(GL_LINES);
glColor4f(0,0.5,0,1); //y -
axis glVertex2d(320,0);
glVertex2d(320,480); //x -
axis


glVertex2d(0,240);
glVertex2d(640,240)
; glEnd(); } void drawObject(int
window){ float x1, y1; cout <<
"Enter point 1 coordinates: "; cin >>
x1 >> y1;

float x2, y2; cout << "Enter point 2
coordinates: "; cin >> x2 >> y2;

float x3, y3; cout << "Enter point 3
coordinates: "; cin >> x3 >> y3;

if (window) { cout <<
"window\n";
glBegin(GL_TRIANGLES);
glColor4f(0.4,0,0.8,1); glVertex2d(x1 +
(xwmax/2), y1 + (ywmax/2)); glVertex2d(x2 +
(xwmax/2), y2 + (ywmax/2)); glVertex2d(x3 +
(xwmax/2), y3 + (ywmax/2)); glEnd();
glFlush(); } else { cout << "viewport\n"; float
sx = xvmax/xwmax, sy = yvmax/ywmax; float
S[3][3] = {{sx, 0, 0}, {0, sy, 0}, {0, 0, 1}};
float T[3][3] = {{x1, y1, 1}, {x2, y2, 1}, {x3,
y3, 1}}; float R[3][3] = {{0, 0, 0}, {0, 0, 0},
{0, 0, 0}};

for (int i = 0 ; i < 3 ; i++)
{ for (int j = 0; j < 3;
j++)
{ for (int k = 0; k < 3;
k++)
```

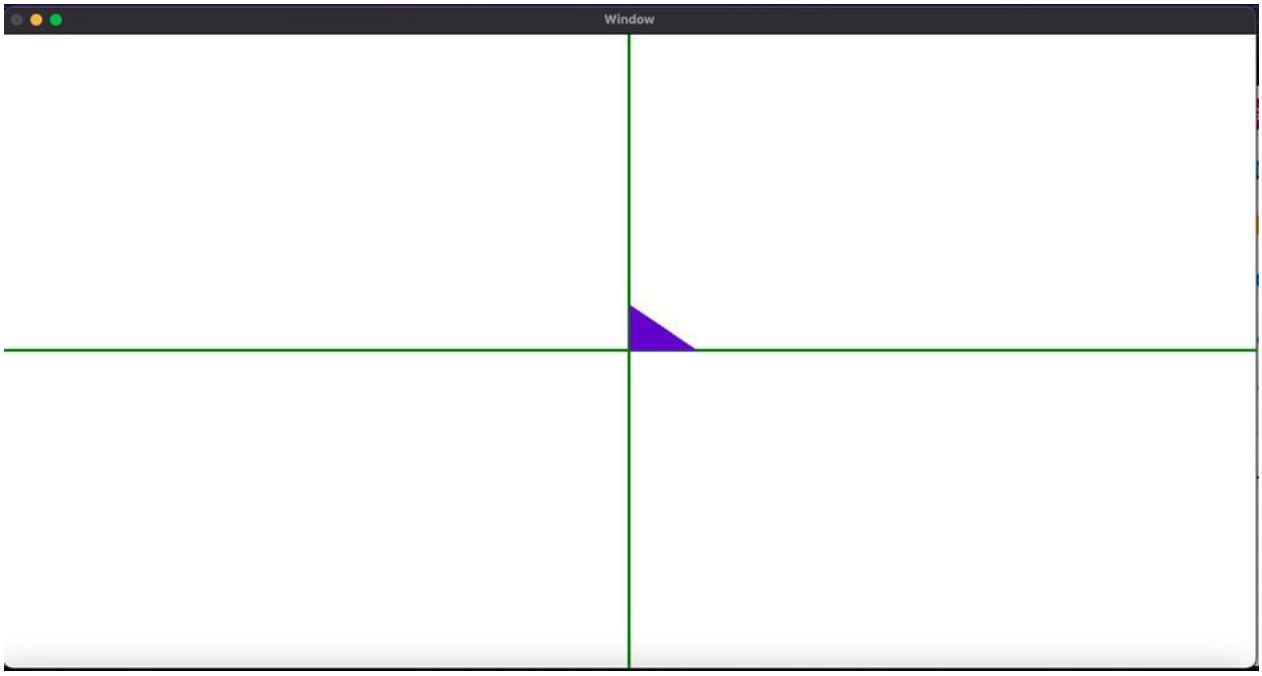
```
{
R[i][j] += S[i][k] * T[k][j];
}
} }
glBegin(GL_TRIANGLES);
glColor4f(0,0,0.8,1);



glVertex2d(R[0][0] + (xvmax/2), R[0][1] + (yvmax/2));
glVertex2d(R[1][0] + (xvmax/2), R[1][1] + (yvmax/2));
glVertex2d(R[2][0] + (xvmax/2), R[2][1] + (yvmax/2));
glEnd(); glFlush();
}

} void plotWindow_window() {
myInit_window();
glClear(GL_COLOR_BUFFER_BIT);
displayaxes_window();
drawObject(1);
glFlush();
glutSwapBuffers()
;
} void plotWindow_viewport() {
myInit_viewport();
glClear(GL_COLOR_BUFFER_BIT);
displayaxes_viewport();
drawObject(0);
glFlush();
glutSwapBuffers()
;
} int main(int argc, char* argv[])
{ glutInit(&argc, argv);
glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGBA);

glutInitWindowSize(xwmax, ywmax); int
window = glutCreateWindow("Window");

glutInitWindowSize(xvmax, yvmax); int
viewport = glutCreateWindow("Viewport");
```

```
glutSetWindow(window);
glutDisplayFunc(plotWindow_window);

glutSetWindow(viewport);
glutDisplayFunc(plotWindow_viewport);


glutMainLoop();
return 1; }
```

Output:

```
Enter point 1 coordinates: 0 0
Enter point 2 coordinates: 0 70
Enter point 3 coordinates: 70 0
window
Enter point 1 coordinates: 0 0
Enter point 2 coordinates: 0 70
Enter point 3 coordinates: 70 0
viewport
```

Window:



Viewport: