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Computer Science Department
قسم الحاسب الآلي

CS Department

Computer Graphics Course, 3-6803430

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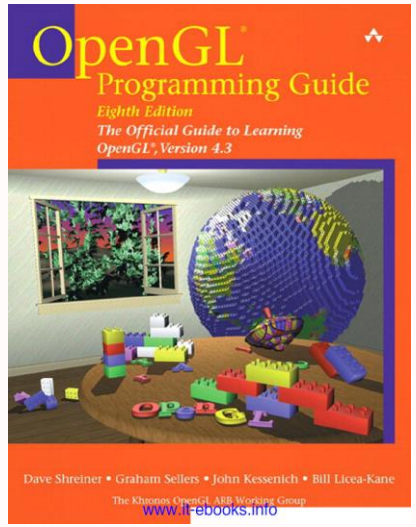
References

- *Lab Lectures, Computer Graphics, Taif University, Faculty Of Computers And Information Technology, TA. Maha Thafar &TA. Haifa Alshehri, TA.Sohair Soliman & L.Shakila Bano.*
- *OpenGL Programming Guide: The Official Guide to Learning OpenGL, Versions 4.3, 8th edition, Dave Shreiner, Graham Sellers, John Kessenich, Bill Licea-Kane & The Khronos OpenGL ARB Working Group, Addison-Wesley.*



Lecture Eight

The Other Transformations in OpenGL

content

1. Rotate Objects using Modeling Transformation
2. Scale Objects using Modeling Transformation
3. Rotate 3D Teapot Program
4. Order of Transformation
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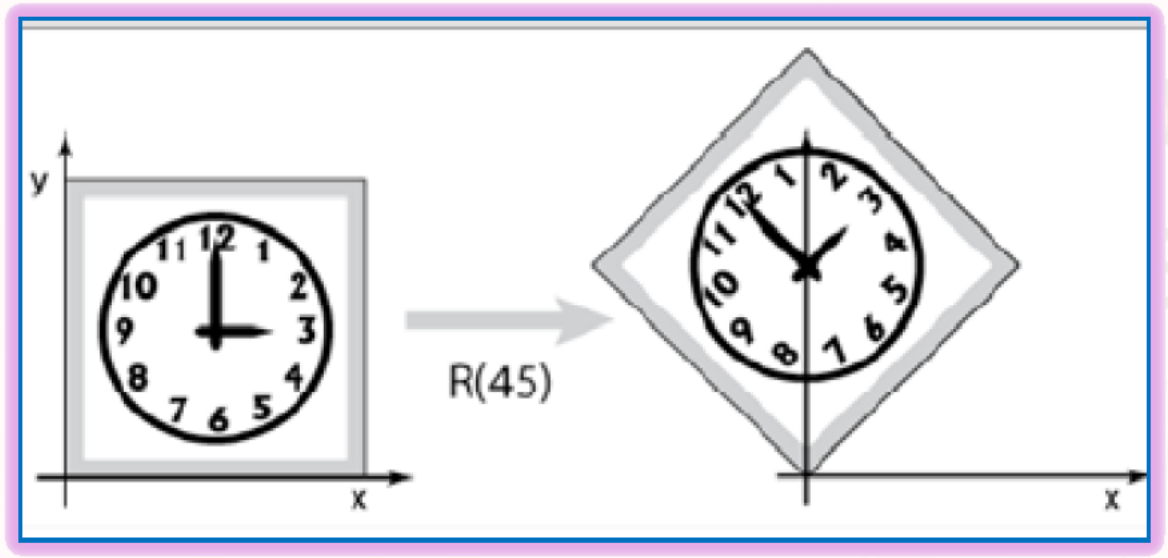
6. Put Multiple Images in One Window Using View Port Functions Program

Rotate Objects using Modeling Transformation

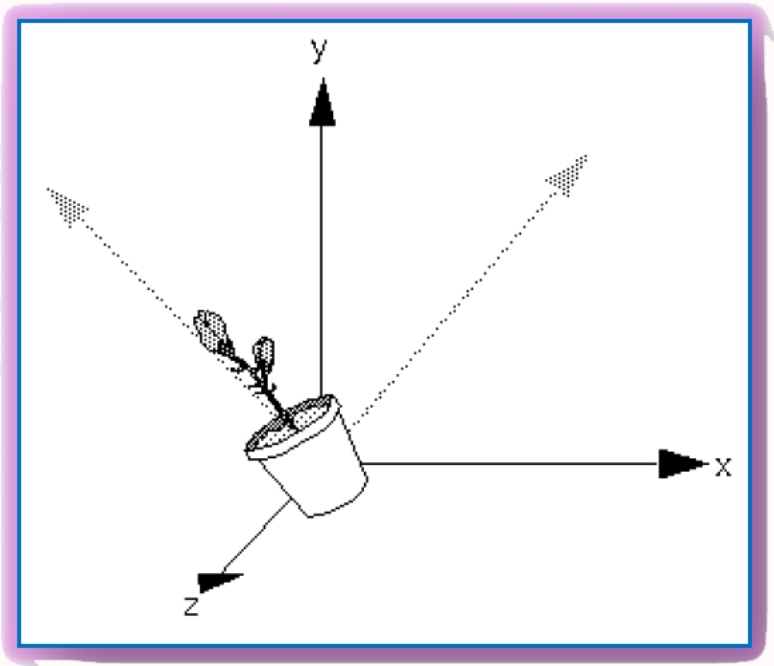
- In order to **rotate** an object
- You have to rotate the coordinate system (e.g. rotation of 40° around the Z axis)
- You draw the object in the rotated coordinate system
- The Rotation function: **void glRotatef(theta, x,y,z)**
- **Example: glRotatef(45 ,0 ,1 ,0);** //Rotate 45 deg around the y axis
- **Note:** The argument of x , y and z can take only the values (**0 , 1 or -1)** means rotate around the given axis.

Rotate Objects using Modeling Transformation

2D



3D

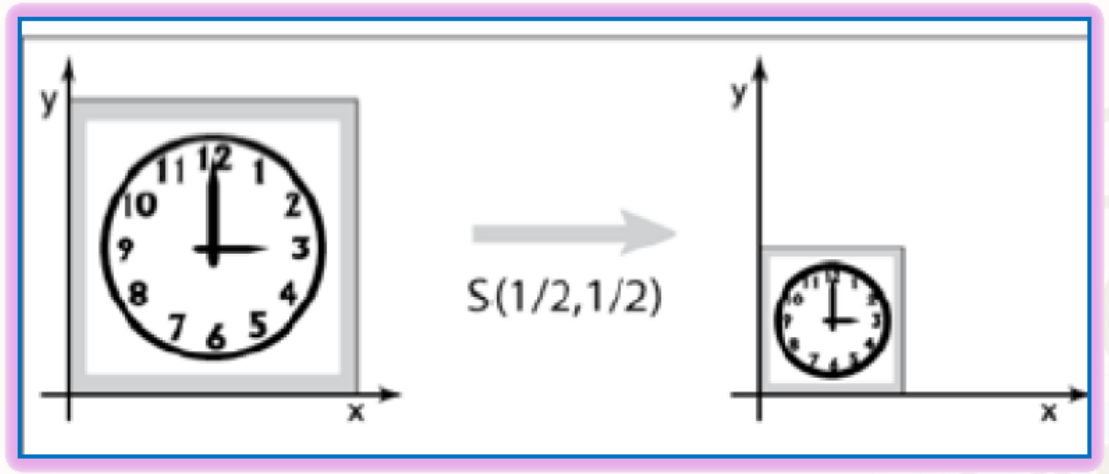


Scale Objects using Modeling Transformation

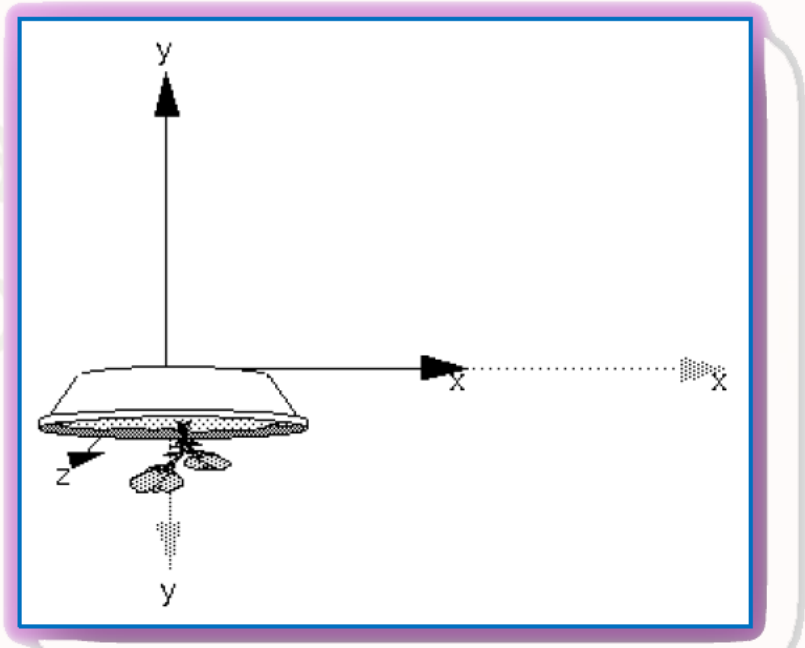
- In order to scale an object
- You first scale the coordinate system (e.g. uniform scaling of 1/2)
- You draw the object in the scaled coordinate system
- the Scale function: **void glScalef(sx ,sy , sz).**
- **Example: glScalef(2, 1 ,1); //scale the x-axis by 2, don't scale the y and z axes**

Scale Objects using Modeling Transformation

2D



3D



Rotate 3D Teapot Program

```
#include<windows.h>
#include<GL/glut.h>

void Draw() {
glClear(GL_COLOR_BUFFER_BIT);
gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
glColor3f(1.0,0.5,0.5); //Pink Color
glutSolidTeapot(4); //Draw the Teapot
glRotatef(60, 1, 1, 0); //Rotate the Teapot
glColor3f(1, 0.2, 0.2); //Color after the rotation
glutSolidTeapot(4); //Redraw the Teapot
glFlush();
}
void init() {
    glClearColor(1, 0.9, 0.8, 0.0);
    glShadeModel(GL_FLAT); //Use one Color.
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-2, 2, -3, 3, 1, 20);
    glMatrixMode(GL_MODELVIEW);
}
int main() {
glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
glutInitWindowSize(500, 500);
glutInitWindowPosition(0,0);
glutCreateWindow("Rotating a Teapot");
init();
glutDisplayFunc(Draw);
glutMainLoop();
return 0;
}
```

Rotate 3D Teapot Program

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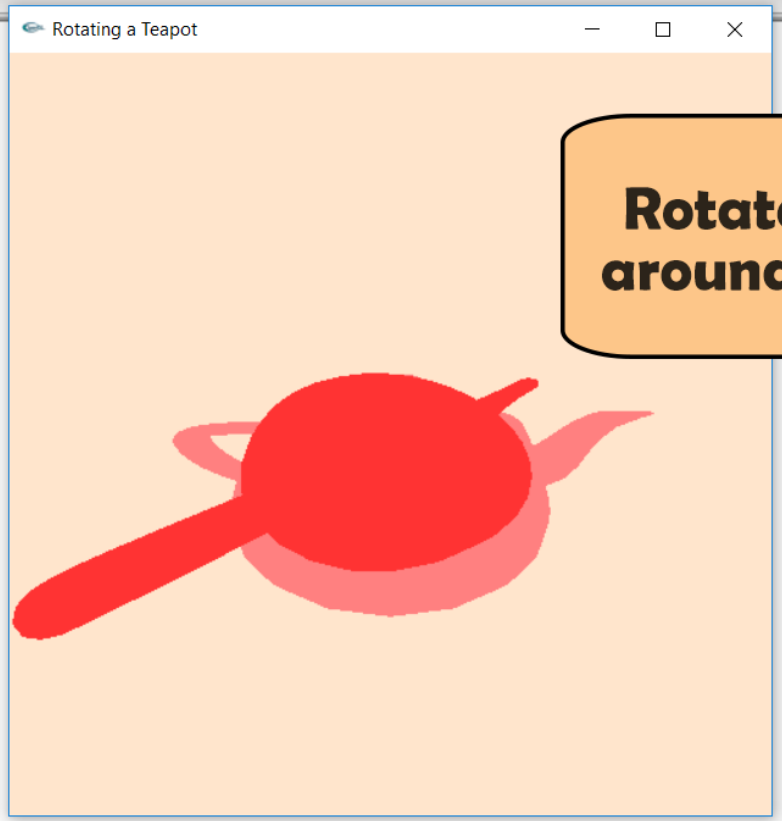
*Rotate3DTeapot.cpp

```
1  #include<windows.h>
2  #include<GL/glut.h>
3
4  void Draw() {
5  glClear(GL_COLOR_BUFFER_BIT);
6  gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
7  glColor3f(1.0,0.5,0.5); //Pink Color
8  glutSolidTeapot(4); //Draw the Teapot
9  glRotatef(60, 1, 1, 0); //Rotate the Teapot
10 glColor3f(1, 0.2, 0.2); //Color after the rotation
11 glutSolidTeapot(4); //Redraw the Teapot
12 glFlush();
13 }
14 void init() {
15     glClearColor(1, 0.9, 0.8, 0.0);
16     glShadeModel(GL_FLAT); //Use one Color.
17     glMatrixMode(GL_PROJECTION);
18     glLoadIdentity();
19     glFrustum(-2, 2, -3, 3, 1, 20);
20     glMatrixMode(GL_MODELVIEW);
21 }
22 int main() {
23 glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
24 glutInitWindowSize(500, 500);
25 glutInitWindowPosition(0,0);
26 glutCreateWindow("Rotating a Teapot");
27 init();
28 glutDisplayFunc(Draw);
29 glutMainLoop();
30 return 0;
31 }
```



Rotate 60 degree around x and y axis

Rotate 3D Teapot Program

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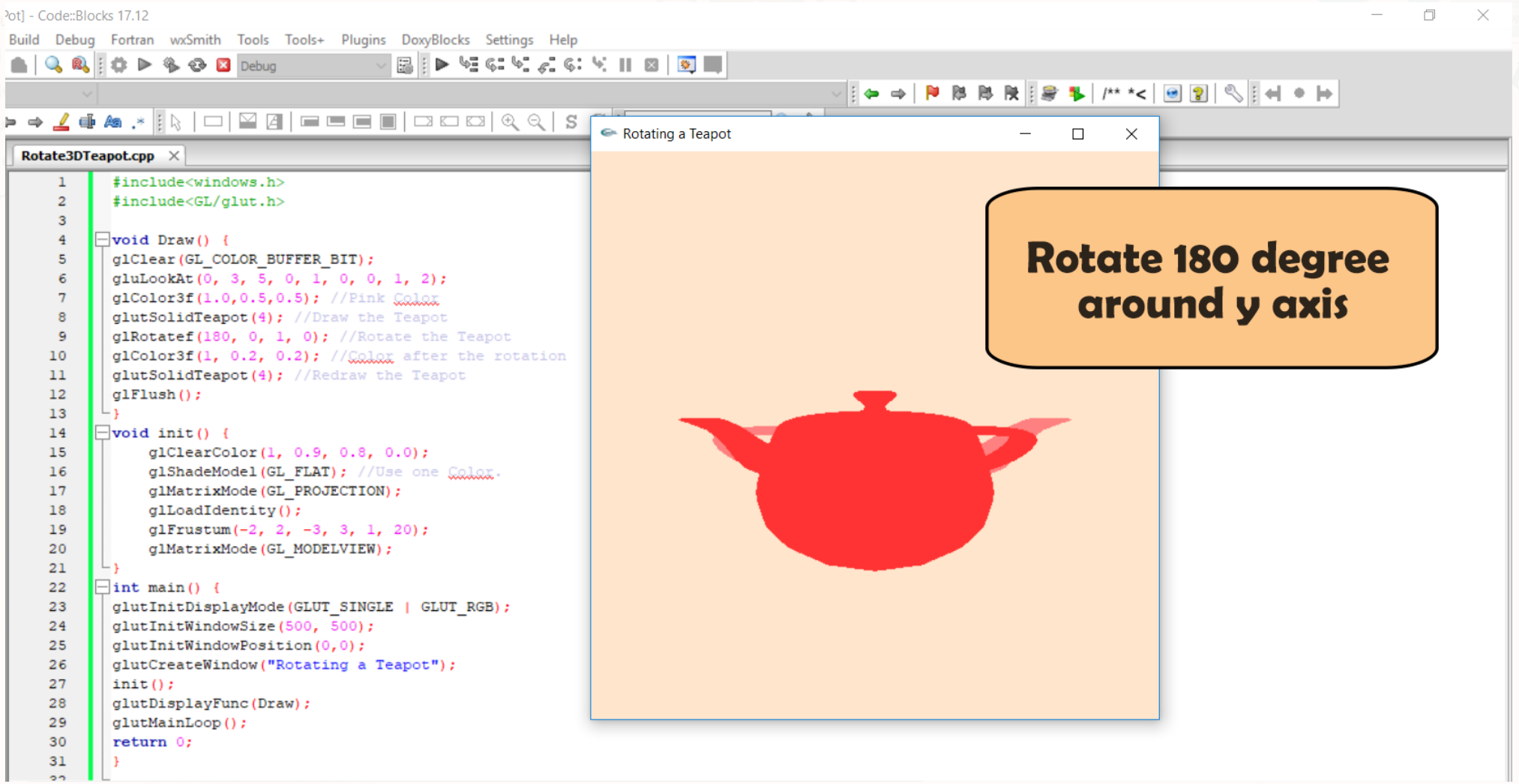
Debug

Rotate3DTeapot.cpp

```
1  #include<windows.h>
2  #include<GL/glut.h>
3
4  void Draw() {
5  glClear(GL_COLOR_BUFFER_BIT);
6  gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
7  glColor3f(1.0,0.5,0.5); //Pink Color
8  glutSolidTeapot(4); //Draw the Teapot
9  //glRotatef(60, 1, 1, 0); //Rotate the Teapot
10 //glColor3f(1, 0.2, 0.2); //Color after the rotation
11 //glutSolidTeapot(4); //Redraw the Teapot
12 glFlush();
13 }
14 void init() {
15     glClearColor(1, 0.9, 0.8, 0.0);
16     glShadeModel(GL_FLAT); //Use one Color.
17     glMatrixMode(GL_PROJECTION);
18     glLoadIdentity();
19     glFrustum(-2, 2, -3, 3, 1, 20);
20     glMatrixMode(GL_MODELVIEW);
21 }
22 int main() {
23 glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
24 glutInitWindowSize(500, 500);
25 glutInitWindowPosition(0,0);
26 glutCreateWindow("Rotating a Teapot");
27 init();
28 glutDisplayFunc(Draw);
29 glutMainLoop();
30 return 0;
31 }
```

One Teapot without Rotate

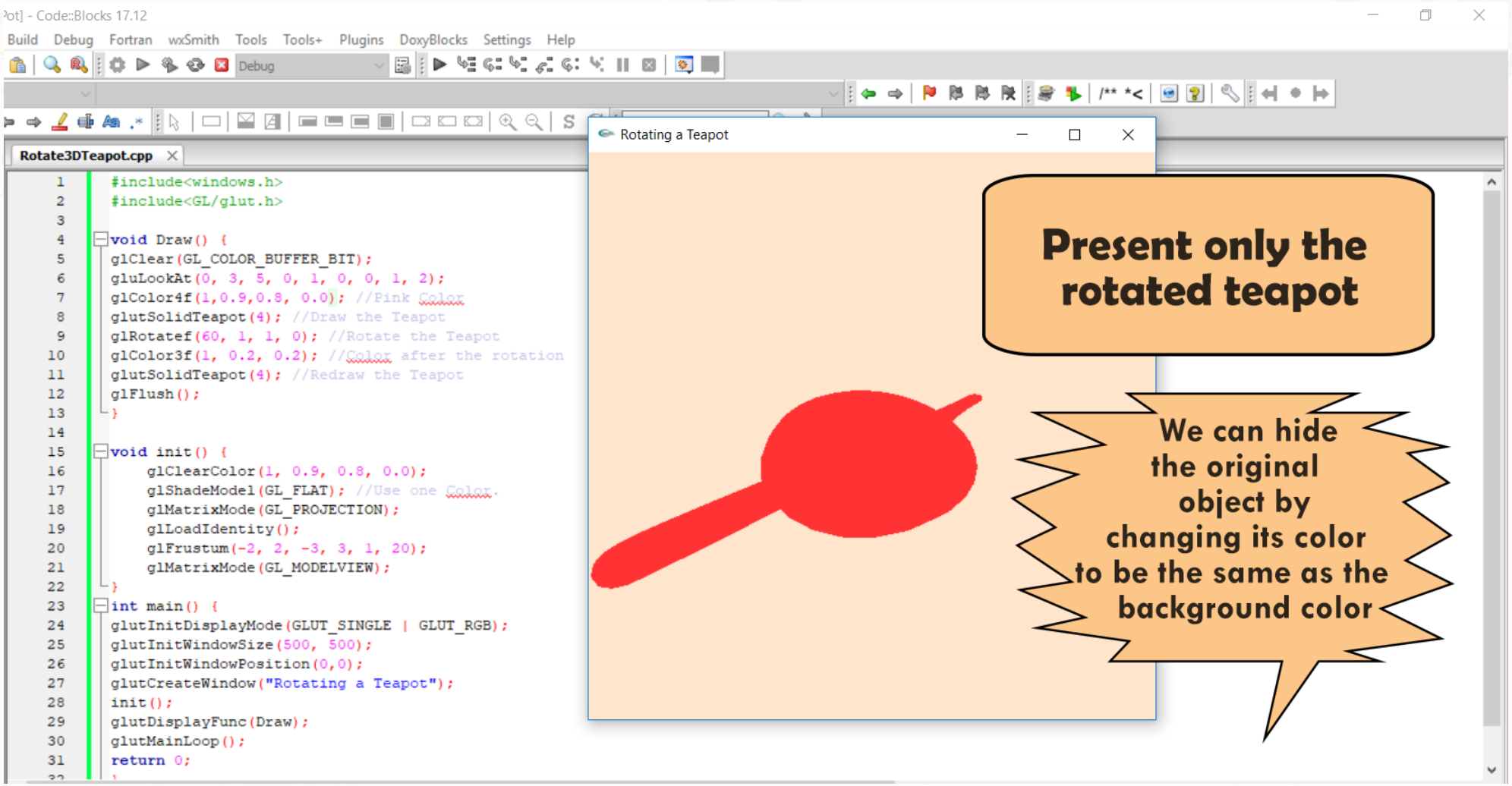
Rotate 3D Teapot Program




```cpp
#include<windows.h>
#include<GL/glut.h>

void Draw() {
glClear(GL_COLOR_BUFFER_BIT);
gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
glColor3f(1.0,0.5,0.5); //Pink Color
glutSolidTeapot(4); //Draw the Teapot
glRotatef(180, 0, 1, 0); //Rotate the Teapot
glColor3f(1, 0.2, 0.2); //Color after the rotation
glutSolidTeapot(4); //Redraw the Teapot
glFlush();
}
void init() {
    glClearColor(1, 0.9, 0.8, 0.0);
    glShadeModel(GL_FLAT); //Use one Color.
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-2, 2, -3, 3, 1, 20);
    glMatrixMode(GL_MODELVIEW);
}
int main() {
glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
glutInitWindowSize(500, 500);
glutInitWindowPosition(0,0);
glutCreateWindow("Rotating a Teapot");
init();
glutDisplayFunc(Draw);
glutMainLoop();
return 0;
}
```

Rotate 3D Teapot Program




```cpp
#include<windows.h>
#include<GL/glut.h>

void Draw() {
glClear(GL_COLOR_BUFFER_BIT);
gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
glColor4f(1,0.9,0.8, 0.0); //Pink Color
glutSolidTeapot(4); //Draw the Teapot
glRotatef(60, 1, 1, 0); //Rotate the Teapot
glColor3f(1, 0.2, 0.2); //Color after the rotation
glutSolidTeapot(4); //Redraw the Teapot
glFlush();
}

void init() {
    glClearColor(1, 0.9, 0.8, 0.0);
    glShadeModel(GL_FLAT); //Use one Color.
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-2, 2, -3, 3, 1, 20);
    glMatrixMode(GL_MODELVIEW);
}
int main() {
glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);
glutInitWindowSize(500, 500);
glutInitWindowPosition(0,0);
glutCreateWindow("Rotating a Teapot");
init();
glutDisplayFunc(Draw);
glutMainLoop();
return 0;
```

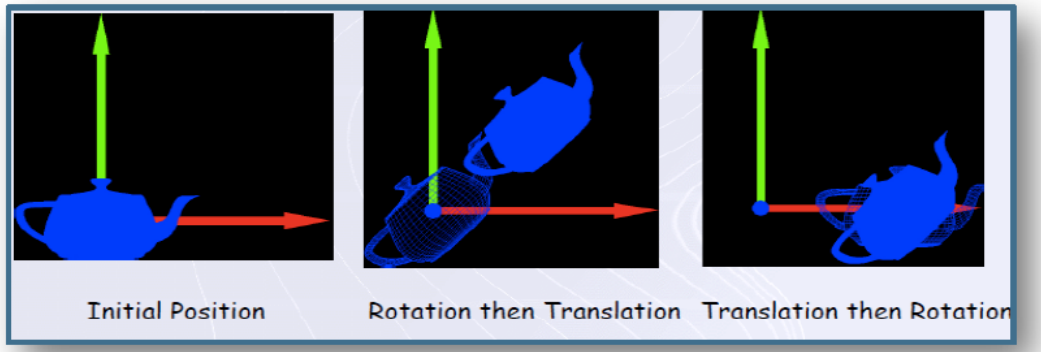
Order of Transformation

- The commands of **modelling transformation** are issued in reverse order of operation.
- Consider the following code fragment:

```
glScalef(2.0f,1.0f,1.0f);              //This is performed last
glTranslatef(5.0f,0.0f,0.0);           //This is performed second
glRotatef(45.0f,0.0f,1.0f,0.0f);       //This is performed first
glutWireCube(1.0);
```

- The first operation performed on the cube is the Rotation, followed by the translation followed by the scaling.

  - See the different when we change the order of transformation:



Viewport Transformation

- View port transformation transforms **x** and **y** from normalized device coordinates to window coordinates.

- Note that **z** value are not transformed in this stage , because **z** axis is orthogonal to the window (2D) and **Z** values have no effect in the mapping.

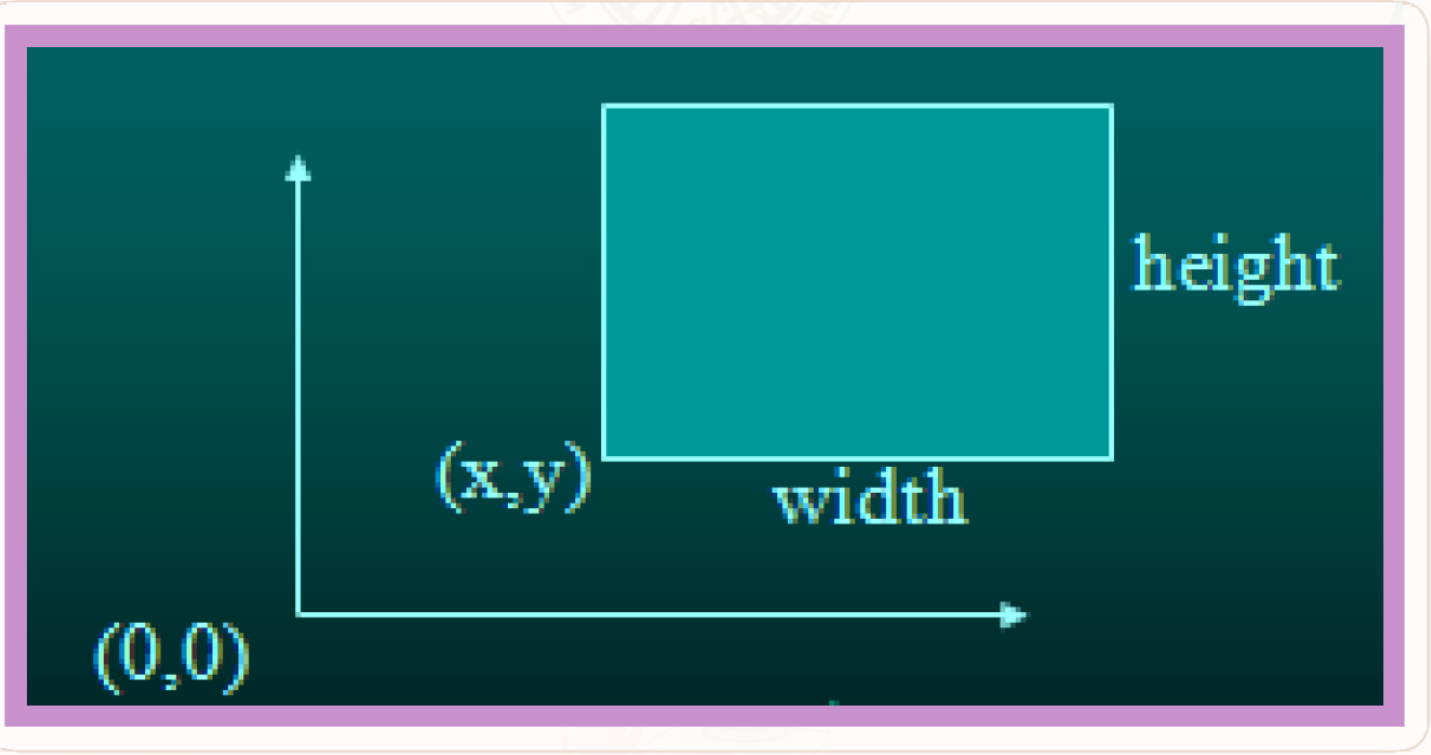
Viewport Transformation

- The function:

void glViewport(GLint x, GLint y, GLsizei width,GLsizei height)

- **x, y:** are normally set to **(0, 0).**
- **width, height:** are normally set to window width and height.
- This means your 2D image size matches your window size. **(view port usually same as window size)**
- You can make your image smaller or bigger than the window by adjusting those values (**E.g**. put multiple images in one window)
- We can use viewport to divide the main window as the games that support tow players.

Viewport Transformation



Put Multiple Images in One Window Using View Port Functions Program

```
#include<windows.h>
#include<GL/glut.h>
#include<math.h>
void Display(void) {
     glColor3f(1, 0.6, 0); //رأس الطائر
     glBegin(GL_POLYGON);
     {    float angle, x2 = 75, y2 = 35, radius = 5;
          for (angle = 0; angle<= 360; angle++)
          glVertex2f(x2+sin(angle)*radius, y2+cos(angle)*radius); }
     glEnd();
     glColor3f(1,1,1); //العيون، الجزء الأبيض
     glBegin(GL_POLYGON);
     {  float angle, x2 = 77, y2 = 37, radius = 2;
        for (angle = 0; angle<= 360; angle++)
        glVertex2f(x2+sin(angle)*radius, y2+cos(angle)*radius); }
     glEnd();
     glColor3f(0,0,0); //العيون، الجزء الأسود
          glBegin(GL_POLYGON);
     {  float angle, x2 = 77, y2 = 37, radius = 1;
        for (angle = 0; angle<= 360; angle++)
        glVertex2f(x2+sin(angle)*radius, y2+cos(angle)*radius); }
     glEnd();
     glColor3f(1, 0.6, 0); //جسم الطائر
     glBegin(GL_POLYGON);
     glVertex2f(73,30);
     glVertex2f(77,30);
     glVertex2f(80,25);
     glVertex2f(75,20);
     glVertex2f(60,20);
     glEnd();
     glColor3f(1, 0.6, 0); //الذيل
     glBegin(GL_TRIANGLES);
     glVertex2f(55,25);
     glVertex2f(50,23);
     glVertex2f(60,20);
     glEnd();
     glColor3f(0.5, 0.2, 0.0);  //المنقار
     glLineWidth(2);
     glBegin(GL_LINES);
     glVertex2f(80, 33);
     glVertex2f(84, 31);
     glEnd();
     glColor3f(0.5, 0.2, 0.0);
     glBegin(GL_TRIANGLES);
     glVertex2f(80,33);
     glVertex2f(80,35);
     glVertex2f(85,35);
     glEnd();
     glLineWidth(3);  //أرجل الطائر
     glBegin(GL_LINES);
     glColor3f(0.5, 0.2, 0.0);
     glVertex2i(75,20);
     glVertex2i(75,13);
     glVertex2i(75,15);
     glVertex2i(77,15);
     glVertex2i(75,15);
     glVertex2i(73,15);
     glVertex2i(70,20);
     glVertex2i(70,13);
     glVertex2i(70,15);
     glVertex2i(72,15);
     glVertex2i(70,15);
     glVertex2i(68,15);
    glEnd();}
```

```
void init() {
glClearColor(0.6,0.9,0.5,0);
glClear(GL_COLOR_BUFFER_BIT |
GL_DEPTH_BUFFER_BIT);
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
glOrtho(40, 100, -10, 60, -20,
20);
glMatrixMode(GL_MODELVIEW);
glViewport(0,0,100,200);
//النافذة الأولى
glLoadIdentity();
glTranslatef(-30, -10, 0);
glScalef(1.5, 1.5, 1.5);
Display();
glViewport(100,0,100,100);
//النافذة الثانية
glLoadIdentity();
glTranslatef(-27, 0, 0);
glScalef(1.5, 1.5, 1.5);
Display();
glViewport(100,100,100,100);
//النافذة الثالثة
glLoadIdentity();
Display();
glTranslatef(10, -10, 0);
Display();
glutSwapBuffers(); }
int main() {
glutInitDisplayMode(GLUT_DEPTH |
GLUT_DOUBLE | GLUT_RGB);
glutInitWindowSize(300, 300);
glutInitWindowPosition(100, 100);
glutCreateWindow("Some Birds");
glutDisplayFunc(init);
glutMainLoop();}
```

Put Multiple Images in One Window Using View Port Functions Program

iewPort.cpp [MultipleImagesInOneWindowUsingViewPort] - Code::Blocks 17.12

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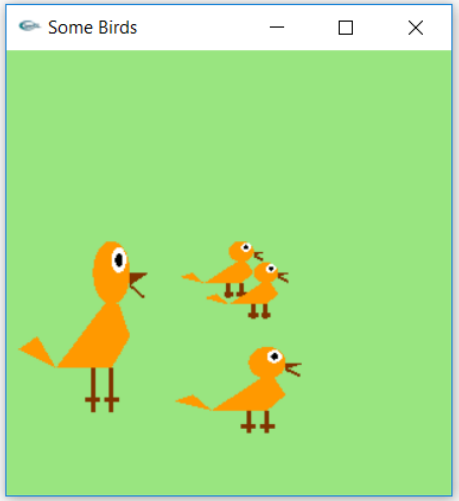
MultipleImagesInOneWindowUsingViewPort.cpp

```
#include<windows.h>
#include<GL/glut.h>
#include<math.h>
void Display(void) {
    //رأس الطائر
    glColor3f(1, 0.6, 0);
    glBegin(GL_POLYGON);
    {
        float angle, x2 = 75, y2 = 35, radius = 5;
        for (angle = 0; angle<= 360; angle++)
           glVertex2f(x2+sin(angle)*radius, y2+cos(angle)*radius);
    }
    glEnd();
    //العين الجزء الأبيض
    glColor3f(1,1,1);
    glBegin(GL_POLYGON);
    {
       float angle, x2 = 77, y2 = 37, radius = 2;
       for (angle = 0; angle<= 360; angle++)
       glVertex2f(x2+sin(angle)*radius, y2+cos(angle)*radius);
    }
    glEnd();
    //العين الجزء الأسود
    glColor3f(0,0,0);
        glBegin(GL_POLYGON);
    {
       float angle, x2 = 77, y2 = 37, radius = 1;
       for (angle = 0; angle<= 360; angle++)
       glVertex2f(x2+sin(angle)*radius, y2+cos(angle)*radius);
    }
    glEnd();
    //جسم الطائر
```



Put Multiple Images in One Window Using View Port Functions Program

ViewPort.cpp [MultipleImagesInOneWindowUsingViewPort] - Code::Blocks 17.12

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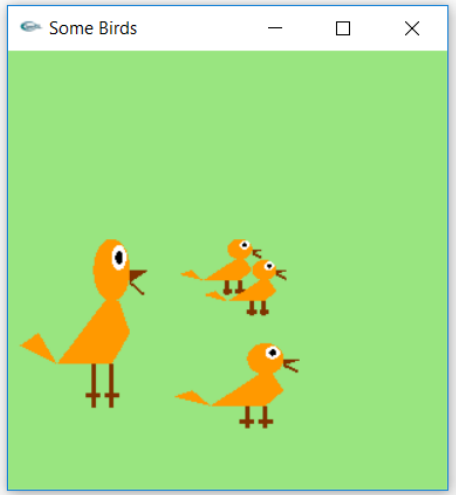
MultipleImagesInOneWindowUsingViewPort.cpp

```
32      //جسم الطائر
33      glColor3f(1, 0.6, 0);
34      glBegin(GL_POLYGON);
35      glVertex2f(73,30);
36      glVertex2f(77,30);
37      glVertex2f(80,25);
38      glVertex2f(75,20);
39      glVertex2f(60,20);
40      glEnd();
41      //الذيل
42      glColor3f(1, 0.6, 0);
43      glBegin(GL_TRIANGLES);
44      glVertex2f(55,25);
45      glVertex2f(50,23);
46      glVertex2f(60,20);
47      glEnd();
48      //المنقار
49      glColor3f(0.5, 0.2, 0.0);
50      glLineWidth(2);
51      glBegin(GL_LINES);
52      glVertex2f(80, 33);
53      glVertex2f(84, 31);
54      glEnd();
55      glColor3f(0.5, 0.2, 0.0);
56      glBegin(GL_TRIANGLES);
57      glVertex2f(80,33);
58      glVertex2f(80,35);
59      glVertex2f(85,35);
60      glEnd();
61      //أرجل الطائر
62      glLineWidth(3);
63      glBegin(GL_LINES);
```



Put Multiple Images in One Window Using View Port Functions Program

ViewPort.cpp [MultipleImagesInOneWindowUsingViewPort] - Code::Blocks 17.12

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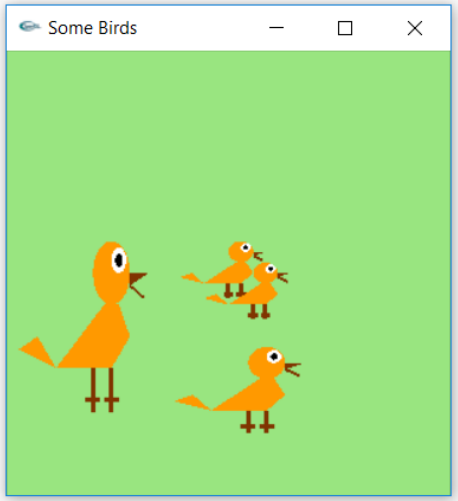
MultipleImagesInOneWindowUsingViewPort.cpp

```
61          //أسمك بالطلب
62          glLineWidth(3);
63          glBegin(GL_LINES);
64          glColor3f(0.5, 0.2, 0.0);
65          glVertex2i(75,20);
66          glVertex2i(75,13);
67          glVertex2i(75,15);
68          glVertex2i(77,15);
69          glVertex2i(75,15);
70          glVertex2i(73,15);
71          glVertex2i(70,20);
72          glVertex2i(70,13);
73          glVertex2i(70,15);
74          glVertex2i(72,15);
75          glVertex2i(70,15);
76          glVertex2i(68,15);
77        glEnd();
78
79          }
80  void init() {
81  glClearColor(0.6,0.9,0.5,0);
82  glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
83  glMatrixMode(GL_PROJECTION);
84  glLoadIdentity();
85  glOrtho(40, 100, -10, 60, -20, 20);
86  glMatrixMode(GL_MODELVIEW);
87  //للنافذة الأولى
88  glViewport(0,0,100,200);
89  glLoadIdentity();
90  glTranslatef(-30, -10, 0);
91  glScalef(1.5, 1.5, 1.5);
92  Display();
```



Put Multiple Images in One Window Using View Port Functions Program

ViewPort.cpp [MultipleImagesInOneWindowUsingViewPort] - Code::Blocks 17.12

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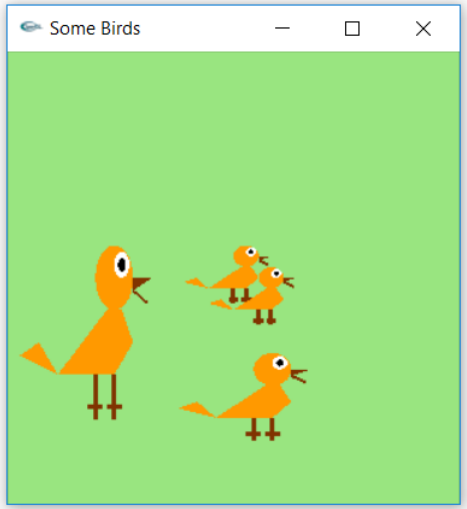
MultipleImagesInOneWindowUsingViewPort.cpp

```
84  glLoadIdentity();
85  glOrtho(40, 100, -10, 60, -20, 20);
86  glMatrixMode(GL_MODELVIEW);
87  //النافذة الأولى
88  glViewport(0,0,100,200);
89  glLoadIdentity();
90  glTranslatef(-30, -10, 0);
91  glScalef(1.5, 1.5, 1.5);
92  Display();
93  //النافذة الثانية
94  glViewport(100,0,100,100);
95  glLoadIdentity();
96  glTranslatef(-27, 0, 0);
97  glScalef(1.5, 1.5, 1.5);
98  Display();
99  //النافذة الثالثة
100 glViewport(100,100,100,100);
101 glLoadIdentity();
102 Display();
103 glTranslatef(10, -10, 0);
104 Display();
105 glutSwapBuffers();
106 }
107
108 int main() {
109 glutInitDisplayMode(GLUT_DEPTH | GLUT_DOUBLE | GLUT_RGB);
110 glutInitWindowSize(300, 300);
111 glutInitWindowPosition(100, 100);
112 glutCreateWindow("Some Birds");
113 glutDisplayFunc(init);
114 glutMainLoop();
115 }
```



Exercise

- **Using OpenGL, draw a brown Teapot with size = 5, then perform the following:**
  - **Rotate the Teapot 150 degree aroud y axis**
  - **Change the color of the Rotated Teapot to Orange.**
  - **Display only the Rotated Teapot in Window.**

وصلى الله وبارك على نبينا محمد

The End Summary of Lecture Eight

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