Homework 2 Report

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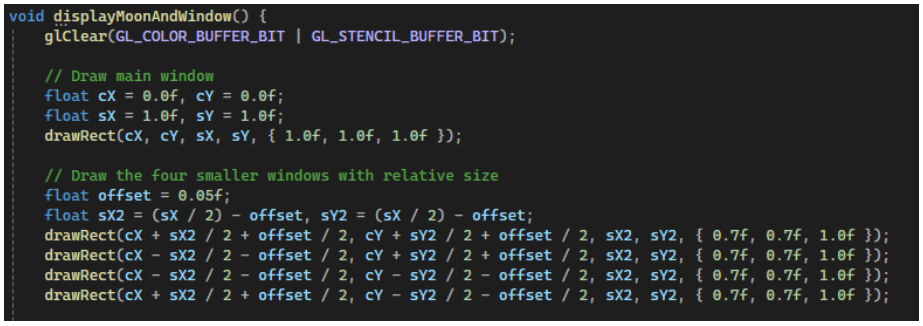
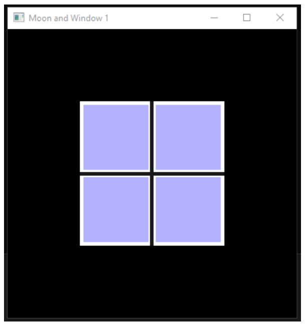
In this homework project, I apologize that my implementation may be varied from the sample instruction. I just try to be more creative.

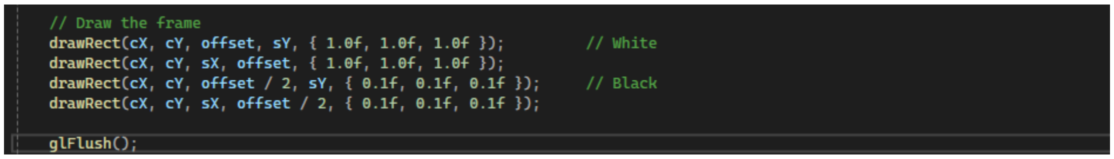
1. Create a window

The first thing I do is create window. First, I draw the white rectangle as the main background of the window using previous drawRect() function with the size of half of the application window (200x200 px). Second, I draw four parts of glasses and use light blue color. Instead of hard-coded size, I write relative size so that it can be more dynamic. We can also change the offset (the size of the crossing frame on the window). So, it becomes like this:



```
void displayMoonAndWindow() {
    glClear(GL_COLOR_BUFFER_BIT | GL_STENCIL_BUFFER_BIT);

    // Draw main window
    float cX = 0.0f, cY = 0.0f;
    float sX = 1.0f, sY = 1.0f;
    drawRect(cX, cY, sX, sY, { 1.0f, 1.0f, 1.0f });

    // Draw the four smaller windows with relative size
    float offset = 0.05f;
    float sX2 = (sX / 2) - offset, sY2 = (sX / 2) - offset;
    drawRect(cX + sX2 / 2 + offset / 2, cY + sY2 / 2 + offset / 2, sX2, sY2, { 0.7f, 0.7f, 1.0f });
    drawRect(cX - sX2 / 2 - offset / 2, cY + sY2 / 2 + offset / 2, sX2, sY2, { 0.7f, 0.7f, 1.0f });
    drawRect(cX - sX2 / 2 - offset / 2, cY - sY2 / 2 - offset / 2, sX2, sY2, { 0.7f, 0.7f, 1.0f });
    drawRect(cX + sX2 / 2 + offset / 2, cY - sY2 / 2 - offset / 2, sX2, sY2, { 0.7f, 0.7f, 1.0f });
```

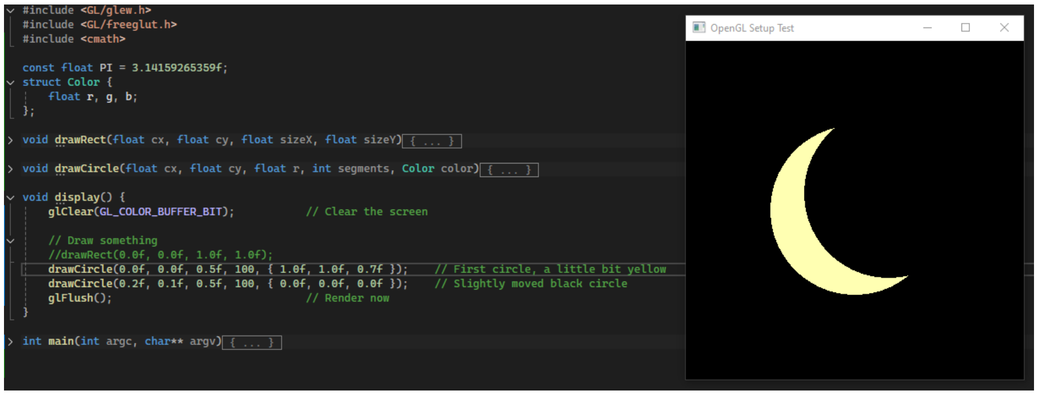




```
    // Draw the frame
    drawRect(cX, cY, offset, sY, { 1.0f, 1.0f, 1.0f });          // White
    drawRect(cX, cY, sX, offset, { 1.0f, 1.0f, 1.0f });
    drawRect(cX, cY, offset / 2, sY, { 0.1f, 0.1f, 0.1f });      // Black
    drawRect(cX, cY, sX, offset / 2, { 0.1f, 0.1f, 0.1f });

    glFlush();
```

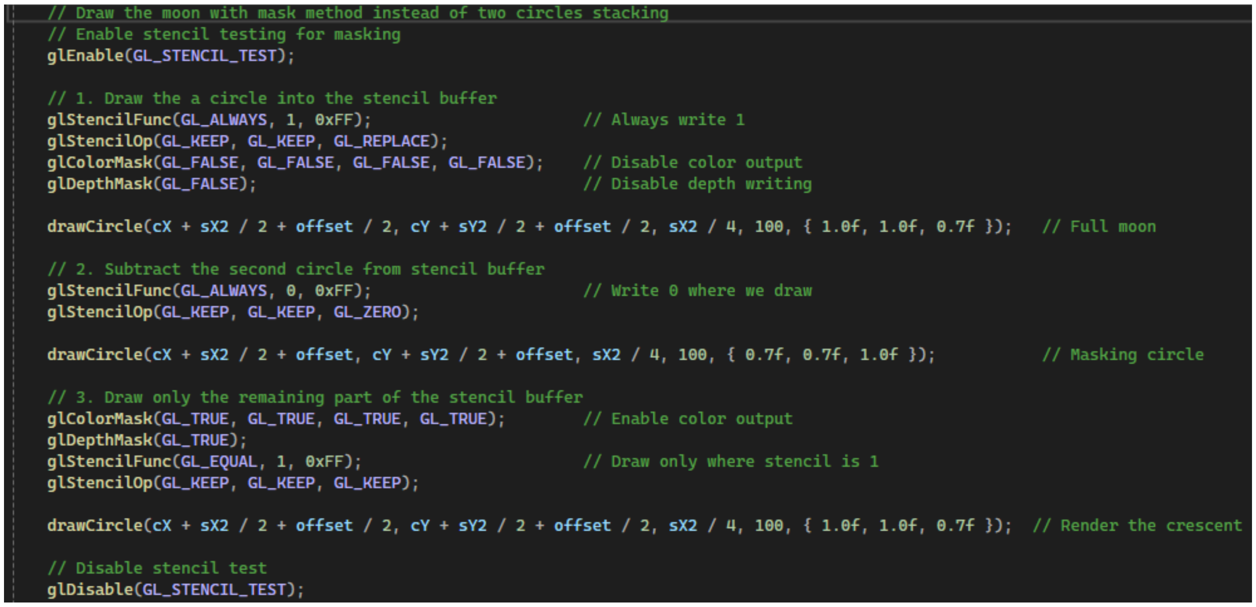
2. Draw a Crescent Moon

Instead of using the same technique, stacking, I use masking. The previous method is shown below, where I literally simply just draw 2 circles. However, because there are two different background colors, I must use masking. This is the previous function:



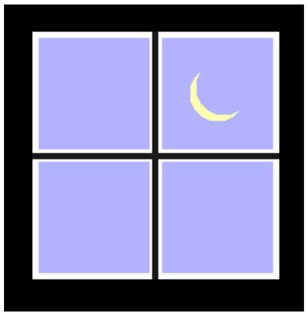
```
#include <GL/glew.h>
#include <GL/freeglut.h>
#include <cmath>

const float PI = 3.14159265359f;
struct Color {
    float r, g, b;
};

void drawRect(float cx, float cy, float sizeX, float sizeY){ ... }

void drawCircle(float cx, float cy, float r, int segments, Color color){ ... }

void display() {
    glClear(GL_COLOR_BUFFER_BIT);           // Clear the screen

    // Draw something
    //drawRect(0.0f, 0.0f, 1.0f, 1.0f);
    drawCircle(0.0f, 0.0f, 0.5f, 100, { 1.0f, 1.0f, 0.7f });    // First circle, a little bit yellow
    drawCircle(0.2f, 0.1f, 0.5f, 100, { 0.0f, 0.0f, 0.0f });    // Slightly moved black circle
    glFlush();                              // Render now
}

int main(int argc, char** argv){ ... }
```

Therefore, I use the stencil buffer from OpenGL to handle the masking operation. First, I need to enable the glstenscil. Then setup some parameters regarding the color mode and the depth. This will define the output. Next, I draw the full circle and feed it to the buffer. Second, I do subtraction operation to the circle with the new slightly-moved one. The third step is to draw the remaining circle that have been subtracted.



```
    // Draw the moon with mask method instead of two circles stacking
    // Enable stencil testing for masking
    glEnable(GL_STENCIL_TEST);

    // 1. Draw the a circle into the stencil buffer
    glStencilFunc(GL_ALWAYS, 1, 0xFF);                   // Always write 1
    glStencilOp(GL_KEEP, GL_KEEP, GL_REPLACE);
    glColorMask(GL_FALSE, GL_FALSE, GL_FALSE, GL_FALSE);    // Disable color output
    glDepthMask(GL_FALSE);                               // Disable depth writing

    drawCircle(cX + sX2 / 2 + offset / 2, cY + sY2 / 2 + offset / 2, sX2 / 4, 100, { 1.0f, 1.0f, 0.7f });   // Full moon

    // 2. Subtract the second circle from stencil buffer
    glStencilFunc(GL_ALWAYS, 0, 0xFF);                   // Write 0 where we draw
    glStencilOp(GL_KEEP, GL_KEEP, GL_ZERO);

    drawCircle(cX + sX2 / 2 + offset, cY + sY2 / 2 + offset, sX2 / 4, 100, { 0.7f, 0.7f, 1.0f });           // Masking circle

    // 3. Draw only the remaining part of the stencil buffer
    glColorMask(GL_TRUE, GL_TRUE, GL_TRUE, GL_TRUE);        // Enable color output
    glDepthMask(GL_TRUE);
    glStencilFunc(GL_EQUAL, 1, 0xFF);                    // Draw only where stencil is 1
    glStencilOp(GL_KEEP, GL_KEEP, GL_KEEP);

    drawCircle(cX + sX2 / 2 + offset / 2, cY + sY2 / 2 + offset / 2, sX2 / 4, 100, { 1.0f, 1.0f, 0.7f });  // Render the crescent

    // Disable stencil test
    glDisable(GL_STENCIL_TEST);
```

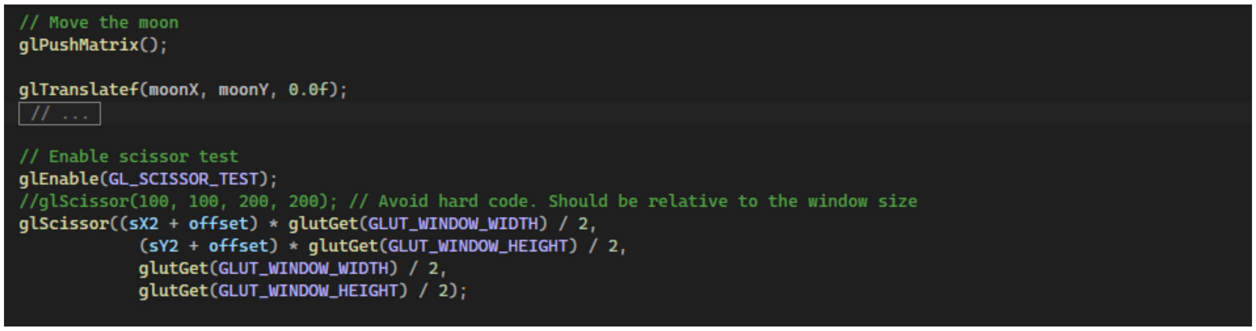
And it will look like this:



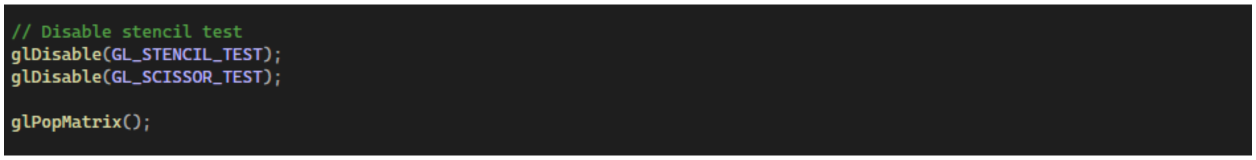
3. Mask on Window & Move the Moon

I was just thinking maybe if I could apply the masking on the window, it would be cool too. First step I do is creating the window buffer to clip the moon and only show on some defined area. Using glscissor, I need to set the origin x and y, and also the size of the clipping window in pixels unit. Therefore, I need to convert the window size to make the clipping window relative.

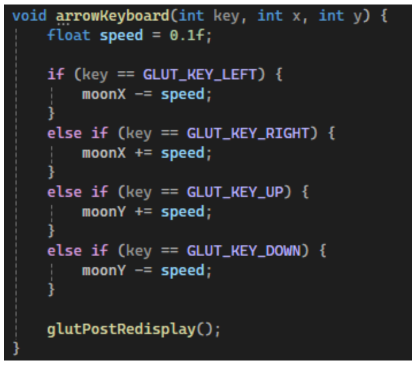
To move the moon, I use gltranslatef function where the new position is simply obtained from the delta position defined in arrwkeyboard function. This function simply add or subs the x and y of the moon.



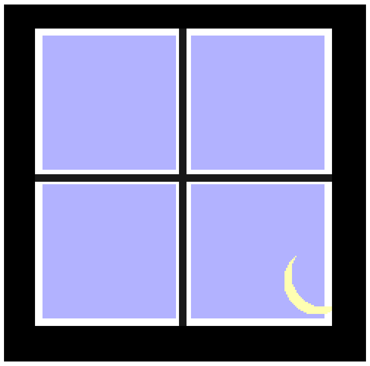
```
// Move the moon
glPushMatrix();

glTranslatef(moonX, moonY, 0.0f);
// ...

// Enable scissor test
glEnable(GL_SCISSOR_TEST);
//glScissor(100, 100, 200, 200); // Avoid hard code. Should be relative to the window size
glScissor((sX2 + offset) * glutGet(GLUT_WINDOW_WIDTH) / 2,
          (sY2 + offset) * glutGet(GLUT_WINDOW_HEIGHT) / 2,
          glutGet(GLUT_WINDOW_WIDTH) / 2,
          glutGet(GLUT_WINDOW_HEIGHT) / 2);
```



```
// Disable stencil test
glDisable(GL_STENCIL_TEST);
glDisable(GL_SCISSOR_TEST);

glPopMatrix();
```

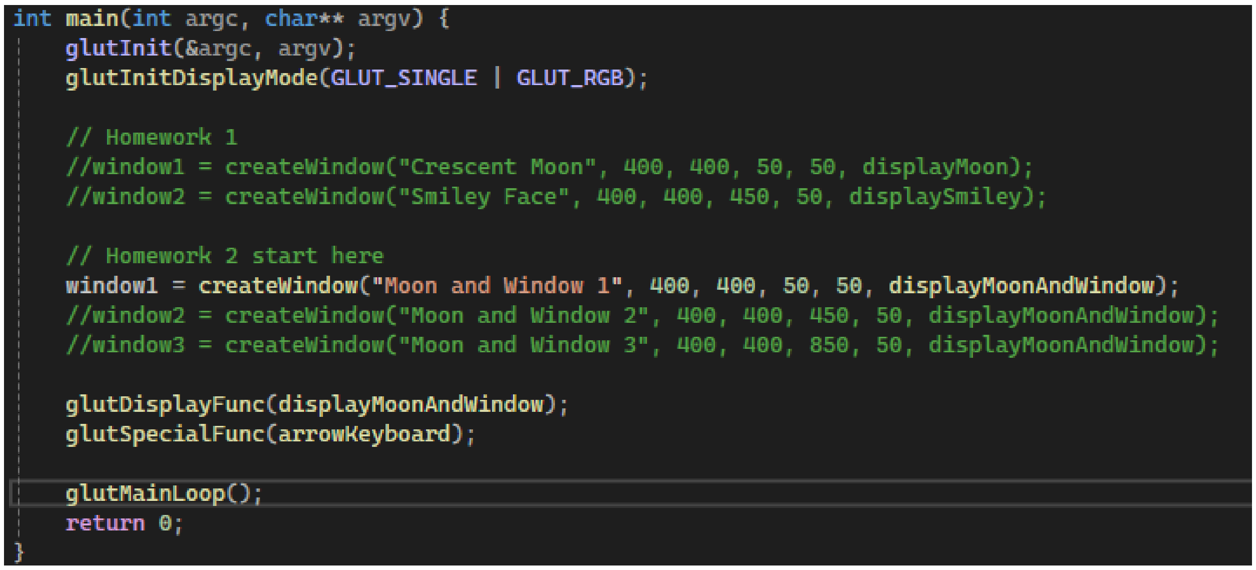


```
void arrowKeyboard(int key, int x, int y) {
    float speed = 0.1f;

    if (key == GLUT_KEY_LEFT) {
        moonX -= speed;
    }
    else if (key == GLUT_KEY_RIGHT) {
        moonX += speed;
    }
    else if (key == GLUT_KEY_UP) {
        moonY += speed;
    }
    else if (key == GLUT_KEY_DOWN) {
        moonY -= speed;
    }

    glutPostRedisplay();
}
```

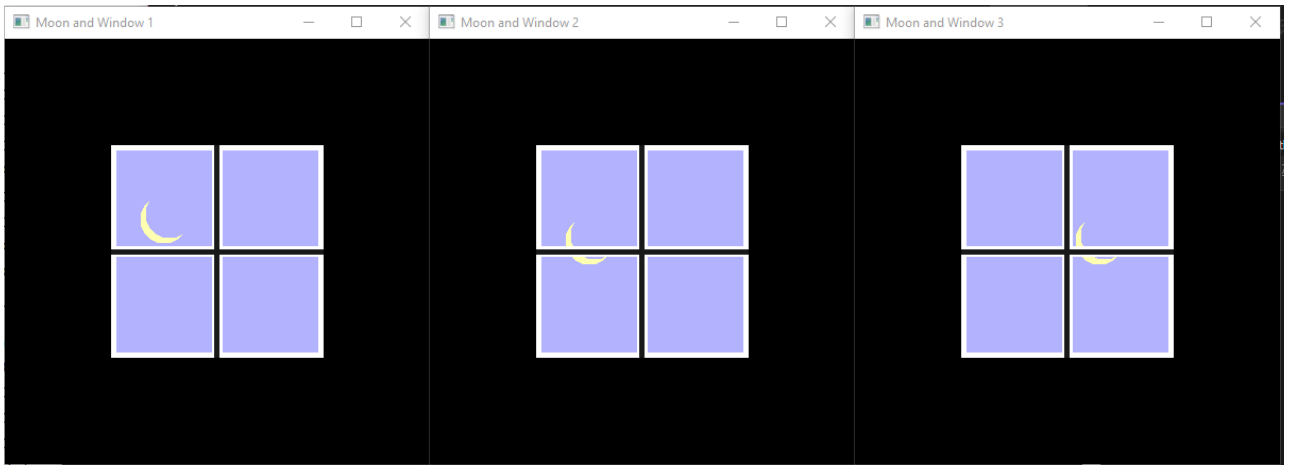


4. Results

The last step is just do the functions callback at main function. Honestly, I just modify the previous homework, so that I don't need to redo some functions.



```
int main(int argc, char** argv) {
    glutInit(&argc, argv);
    glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);

    // Homework 1
    //window1 = createWindow("Crescent Moon", 400, 400, 50, 50, displayMoon);
    //window2 = createWindow("Smiley Face", 400, 400, 450, 50, displaySmiley);

    // Homework 2 start here
    window1 = createWindow("Moon and Window 1", 400, 400, 50, 50, displayMoonAndWindow);
    //window2 = createWindow("Moon and Window 2", 400, 400, 450, 50, displayMoonAndWindow);
    //window3 = createWindow("Moon and Window 3", 400, 400, 850, 50, displayMoonAndWindow);

    glutDisplayFunc(displayMoonAndWindow);
    glutSpecialFunc(arrowKeyboard);

    glutMainLoop();
    return 0;
}
```



I push my code here:

https://github.com/ardiawanbagusharisa/cgopengl/tree/main/OpenGL%20App%202

The complete code:

```
#include <GL/glew.h>
#include <GL/freeglut.h>
#include <cmath>

const float PI = 3.14159265359f;
struct Color {
      float r, g, b;
};

float moonX = 0.0f, moonY = 0.0f;   // Moon's position

int window1, window2, window3;

void drawRect(float cx, float cy, float sizeX, float sizeY, Color color) {
      glColor3f(color.r, color.g, color.b);
      glBegin(GL_QUADS);                                            //
Start drawing a square

      glVertex2f(cx - sizeX / 2, cy - sizeY / 2);           //    Change    the
method to be more parametric
      glVertex2f(cx + sizeX / 2, cy - sizeY / 2);
      glVertex2f(cx + sizeX / 2, cy + sizeY / 2);
      glVertex2f(cx - sizeX / 2, cy + sizeY / 2);

      glEnd();
}

void drawCircle(float cx, float cy, float r, int segments, Color color) {
      glColor3f(color.r, color.g, color.b);
      glBegin(GL_TRIANGLE_FAN);

      for (int i = 0; i <= segments; i++) {
            float theta = 2.0f * PI * float(i) / float(segments); //   Compute
the radian angle
            float x = r * cosf(theta);          // Set coordinates of points on
the perimeter of the circle using polar to cartesian
            float y = r * sinf(theta);
            glVertex2f(x + cx, y + cy);
      }
      glEnd();
}

int createWindow(const char* title, int width, int height, int posX, int posY,
void (*displayFunc)()) {
      glutInitWindowSize(width, height);
      glutInitWindowPosition(posX, posY);
      int windowID = glutCreateWindow(title);
      glewInit();
      glClearColor(0.0f, 0.0f, 0.0f, 1.0f);           // Black background
      glutDisplayFunc(displayFunc);                   // Register the display
function
      return windowID;
}

void displayMoon() {
      glClear(GL_COLOR_BUFFER_BIT);
```

```
	drawCircle(0.0f, 0.0f, 0.5f, 100, { 1.0f, 1.0f, 0.7f });	//	First
circle, a little bit yellow
	drawCircle(0.2f, 0.1f, 0.5f, 100, { 0.0f, 0.0f, 0.0f });	//  Slightly
moved black circle
	glFlush();
}

void displaySmiley() {
	glClear(GL_COLOR_BUFFER_BIT);
	drawCircle(0.0f, 0.0f, 0.6f, 100, { 1.0f, 0.8f, 0.6f });		//
Main face
	drawCircle(-0.275f, 0.275f, 0.2f, 100, { 1.0f, 1.0f, 1.0f });	//
Left eye
	drawCircle(-0.25f, 0.25f, 0.1f, 100, { 0.0f, 0.0f, 0.0f });
	drawCircle(0.275f, 0.275f, 0.2f, 100, { 1.0f, 1.0f, 1.0f });	//
Right eye
	drawCircle(0.25f, 0.25f, 0.1f, 100, { 0.0f, 0.0f, 0.0f });
	drawCircle(0.0f, -0.25f, 0.2f, 100, { 1.0f, 0.0f, 0.0f });		//
Mouth
	drawRect(0.0f, -0.15f, 0.4f, 0.2f, { 1.0f, 0.8f, 0.6f });
	drawCircle(-0.35f, 0.0f, 0.175f, 100, { 1.0f, 0.7f, 0.5f });	//
Cheeks
	drawCircle(0.35f, 0.0f, 0.175f, 100, { 1.0f, 0.7f, 0.5f });
	drawCircle(0.0f, 0.0f, 0.2f, 100, { 1.0f, 0.6f, 0.4f });		//
Nose
	drawCircle(-0.1f, 0.1f, 0.05f, 100, { 1.0f, 1.0f, 1.0f });		//
Highlight
	glFlush();

}

void displayMoonAndWindow() {
	glClear(GL_COLOR_BUFFER_BIT | GL_STENCIL_BUFFER_BIT);

	// Draw main window
	float cX = 0.0f, cY = 0.0f;
	float sX = 1.0f, sY = 1.0f;
	drawRect(cX, cY, sX, sY, { 1.0f, 1.0f, 1.0f });

	// Draw the four smaller windows with relative size
	float offset = 0.05f;
	float sX2 = (sX / 2) - offset, sY2 = (sX / 2) - offset;
	drawRect(cX + sX2 / 2 + offset / 2, cY + sY2 / 2 + offset / 2, sX2, sY2,
{ 0.7f, 0.7f, 1.0f });
	drawRect(cX - sX2 / 2 - offset / 2, cY + sY2 / 2 + offset / 2, sX2, sY2,
{ 0.7f, 0.7f, 1.0f });
	drawRect(cX - sX2 / 2 - offset / 2, cY - sY2 / 2 - offset / 2, sX2, sY2,
{ 0.7f, 0.7f, 1.0f });
	drawRect(cX + sX2 / 2 + offset / 2, cY - sY2 / 2 - offset / 2, sX2, sY2,
{ 0.7f, 0.7f, 1.0f });

	// Move the moon
	glPushMatrix();

	glTranslatef(moonX, moonY, 0.0f);
	// Deleted. Use stencil buffer instead.
	//drawCircle(cX + sX2 / 2 + offset / 2, cY + sY2 / 2 + offset / 2, sX2 / 
4, 100, { 1.0f, 1.0f, 0.7f });
	//drawCircle(cX + sX2 / 2 + offset, cY + sY2 / 2 + offset, sX2 / 4, 100, 
{ 0.7f, 0.7f, 1.0f });

	// Enable scissor test
	glEnable(GL_SCISSOR_TEST);
	//glScissor(100, 100, 200, 200); // Avoid hard code. Should be relative 
to the window size
	glScissor((sX2 + offset) * glutGet(GLUT_WINDOW_WIDTH) / 2,
	          (sY2 + offset) * glutGet(GLUT_WINDOW_HEIGHT) / 2,
	          glutGet(GLUT_WINDOW_WIDTH) / 2,
	          glutGet(GLUT_WINDOW_HEIGHT) / 2);


	// Draw the moon with mask method instead of two circles stacking
	// Enable stencil testing for masking
	glEnable(GL_STENCIL_TEST);

	// 1. Draw the a circle into the stencil buffer
	glStencilFunc(GL_ALWAYS, 1, 0xFF);                                //
Always write 1
	glStencilOp(GL_KEEP, GL_KEEP, GL_REPLACE);
	glColorMask(GL_FALSE, GL_FALSE, GL_FALSE, GL_FALSE);  //  Disable  color 
output
	glDepthMask(GL_FALSE);
	// Disable depth writing

	drawCircle(cX + sX2 / 2 + offset / 2, cY + sY2 / 2 + offset / 2, sX2 / 4, 
100, { 1.0f, 1.0f, 0.7f });   // Full moon

	// 2. Subtract the second circle from stencil buffer
	glStencilFunc(GL_ALWAYS, 0, 0xFF);                                //
Write 0 where we draw
	glStencilOp(GL_KEEP, GL_KEEP, GL_ZERO);

	drawCircle(cX + sX2 / 2 + offset, cY + sY2 / 2 + offset, sX2 / 4, 100, 
{ 0.7f, 0.7f, 1.0f });              // Masking circle

	// 3. Draw only the remaining part of the stencil buffer
	glColorMask(GL_TRUE, GL_TRUE, GL_TRUE, GL_TRUE);            //    Enable 
color output
	glDepthMask(GL_TRUE);
	glStencilFunc(GL_EQUAL, 1, 0xFF);                                 //
Draw only where stencil is 1
	glStencilOp(GL_KEEP, GL_KEEP, GL_KEEP);

	drawCircle(cX + sX2 / 2 + offset / 2, cY + sY2 / 2 + offset / 2, sX2 / 4, 
100, { 1.0f, 1.0f, 0.7f });  // Render the crescent

	// Disable stencil test
	glDisable(GL_STENCIL_TEST);
	glDisable(GL_SCISSOR_TEST);

	glPopMatrix();

	// Draw the frame
	drawRect(cX, cY, offset, sY, { 1.0f, 1.0f, 1.0f });		//
White
	drawRect(cX, cY, sX, offset, { 1.0f, 1.0f, 1.0f });
	drawRect(cX, cY, offset / 2, sY, { 0.1f, 0.1f, 0.1f });		//
Black
	drawRect(cX, cY, sX, offset / 2, { 0.1f, 0.1f, 0.1f });

	glFlush();
}

void arrowKeyboard(int key, int x, int y) {
	float speed = 0.1f;

	if (key == GLUT_KEY_LEFT) {
		moonX -= speed;
	}
	else if (key == GLUT_KEY_RIGHT) {
		moonX += speed;
	}
	else if (key == GLUT_KEY_UP) {
		moonY += speed;
	}
	else if (key == GLUT_KEY_DOWN) {
		moonY -= speed;
	}

	glutPostRedisplay();
}

int main(int argc, char** argv) {
	glutInit(&argc, argv);
	glutInitDisplayMode(GLUT_SINGLE | GLUT_RGB);

	// Homework 1
	//window1 = createWindow("Crescent Moon", 400, 400, 50, 50, displayMoon);
	//window2 = createWindow("Smiley Face", 400, 400, 450, 50, displaySmiley);

	// Homework 2 start here
	window1 = createWindow("Moon and Window 1", 400, 400, 50, 50,
displayMoonAndWindow);
	//window2 = createWindow("Moon and Window 2", 400, 400, 450, 50,
displayMoonAndWindow);
	//window3 = createWindow("Moon and Window 3", 400, 400, 850, 50,
displayMoonAndWindow);

	glutDisplayFunc(displayMoonAndWindow);
	glutSpecialFunc(arrowKeyboard);

	glutMainLoop();
	return 0;
}
```