Kingdom of Saudi Arabia
المملكة العربية السعودية
Ministry of Education
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Umm AlQura University
جامعة أم القرى
Adham University College
الكلية الجامعية بأضم
Computer Science Department
قسم الحاسب الآلي

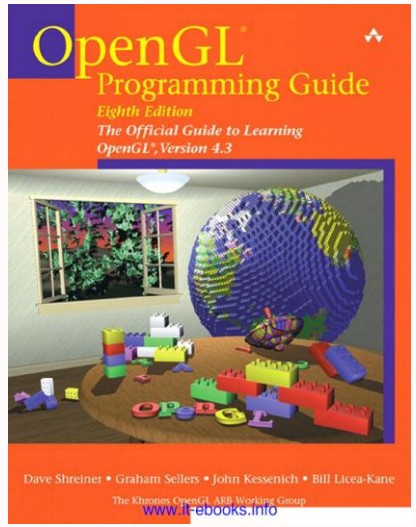
CS Department

Computer Graphics Course, 3-6803430

T.Mariah Khayat

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 Nine

Lighting in OpenGL

content

1. Lighting Principles
2. Types of Lights
3. Light Source
4. Lights Prosperities
5. Material Prosperities
6. A Lighting Program using OpenGL
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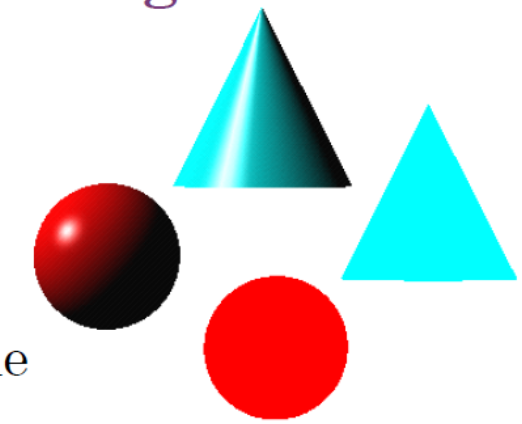
Lighting Principles

- **Lighting simulates how objects reflect light**
  - material composition of object.
  - light's color and position
  - global lighting parameters
    - ambient light
    - two sided lighting
  - available in both color index and RGBA mode



- **How to apply lighting in OpenGL?**
  - **Assign** Normals to vertices.
    Normals define how a surface reflects light `glNormal3f( x,y,z).`
  - **Create**, **position** and **enable** lights.
  - **Select** a lighting model
  - **Define** the material properties of objects in the scene

Types of Lights

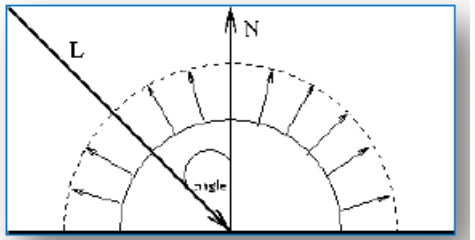
- there are 3 main types of light:

1) Ambient:

- Light scattered by environment.
- Unable to determine direction.
- Based on surfaces in scene

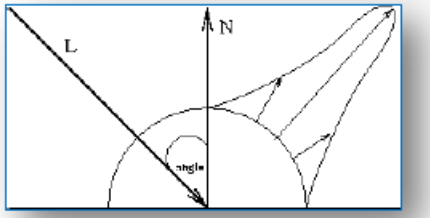
2) Diffuse:

- Coming from one direction.
- Scattered equally in all directions from surface



2) Specular:

- Coming from particular direction.
- Bounce off the surface in particular direction
- Based on law of reflection
- Specularity = shininess



Lights Source

- To Turn on the power of the light use:

```
glEnable(GL_LIGHTING);
```

and Can be **disabled** at any time.

```
glDisable( GL_LIGHTING);
```

- Enable the depth:

```
glEnable(GL_DEPTH_TEST);
```

- Enable and set properties for light sources:
  - Use `glEnable(GL_LIGHT0);` to enable light zero. You can use at most 8 light sources in OpenGL spec. (`GL_LIGHT0` → `GL_LIGHT7`)
  - Use:

```
glLight{if}[v](GLenum light, Glenum pname, TYPE value);
```

and Specify the attribute of light:

- ***light:*** can be `GL_LIGHT0 ~ GL_LIGHT7`
- ***pname :*** (Parameter name) is the characteristic (**property**) of the light
- ***value:*** is the value of pname.

  - *Example:*

```
GLfloat  sourceLight[] = { 0.25, 0.25, 0.25, 1.0 };
glLightfv(GL_LIGHT0,GL_AMBIENT,sourceLight);
```

Lights Prosperities

Color:

- The default values listed for **GL_DIFFUSE** and **GL_SPECULAR** apply only to **GL_LIGHT0.**
- For other lights, the default value is **(0.0, 0.0, 0.0, 1.0)** for both **GL_DIFFUSE** and **GL_SPECULAR.**
- Ambient, diffuse = color of material.
- Specular = usually white.
- Emissive color = light coming from object.

Position: (x, y, z, w)

- **OpenGL supports two types of Lights:**
  1. Local (Point) light sources
  2. Infinite (Directional) light sources

Type of light controlled by w coordinate:

1. W is ZERO, **Directional light,** (x,y,z) specify its direction.
2. W is NONZERO, **Positional light,** (x,y,z) specify the location of the light source

Material Properties

- **Material :** Describe the percentages of the incoming red, green, blue light it reflects on a surface.
- **Material** has different **ambient**, **diffuse** and **specular** colors.
- **Define the material properties for objects in the scene:**
  - `glMaterialfv( face, property, value );`
    - ***face:*** can be : `GL_FRONT, GL_BACK, GL_FRONT_AND_BACK.`
    - ***property(pname):*** identifier of **property** of the light.
    - ***value:*** is the value of pname.

Pname	Def. Value	Meaning
GL_AMBIENT	(0.2, 0.2, 0.2, 1.0)	ambient color of material
GL_DIFFUSE	(0.8, 0.8, 0.8, 1.0)	diffuse color of material
GL_SPECULAR	(0.0, 0.0, 0.0, 1.0)	specular color of material
GL_SHININESS	0.0	specular exponent
GL_EMISSION	(0.0, 0.0, 0.0, 1.0)	emissive color of material

- ***To enable the color of object:*** `glEnable(GL_COLOR_MATERIAL);`

A Lighting Program Using OpenGL

```
#include<windows.h>
#include<GL/glut.h>
void Draw() {
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
    //Lighting Part
    GLfloat mat_specular[] = {0, 0, 0, 0};
    GLfloat light_position[] = {-1, 0, 0, 0};
    glMaterialfv(GL_FRONT, GL_SPECULAR, mat_specular);
    glLightfv(GL_LIGHT0, GL_POSITION, light_position);
    glEnable(GL_LIGHTING);
    glEnable(GL_LIGHT0);
    //Ending of the Lighting Part
    glColor3f(1.0, 1.0, 1.0);
    glutSolidSphere(1.5, 30, 30);
    glTranslatef(0.5, 3, 0.0);
    glColor3f(0,0,0);
    glutSolidTeapot(1);
    glFlush(); }
void init() {
    glClearColor(1, 0.9, 0.8, 0.0);
    glShadeModel(GL_FLAT);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-1, 1, -1, 1, 1, 15);
    glMatrixMode(GL_MODELVIEW); }
int main() {
    glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize (500, 500);
    glutInitWindowPosition(0,0);
    glutCreateWindow("Adding a Light Effects");
    init();
    glutDisplayFunc(Draw);
    glutMainLoop();
    return 0; }
```

A Lighting Program Using OpenGL

```
#include<windows.h>
#include<GL/glut.h>
void Draw() {
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
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    //Lighting Part
    GLfloat mat_specular[] = {0, 0, 0, 0};
    GLfloat light_position[] = {-1, 0, 0, 0};
    glMaterialfv(GL_FRONT, GL_SPECULAR, mat_specular);
    glLightfv(GL_LIGHT0, GL_POSITION, light_position);
    glEnable(GL_LIGHTING);
    glEnable(GL_LIGHT0);
    //Ending of the Lighting Part
    glColor3f(1.0, 1.0, 1.0);
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    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-1, 1, -1, 1, 1, 15);
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int main() {
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    glutMainLoop();
    return 0; }
```

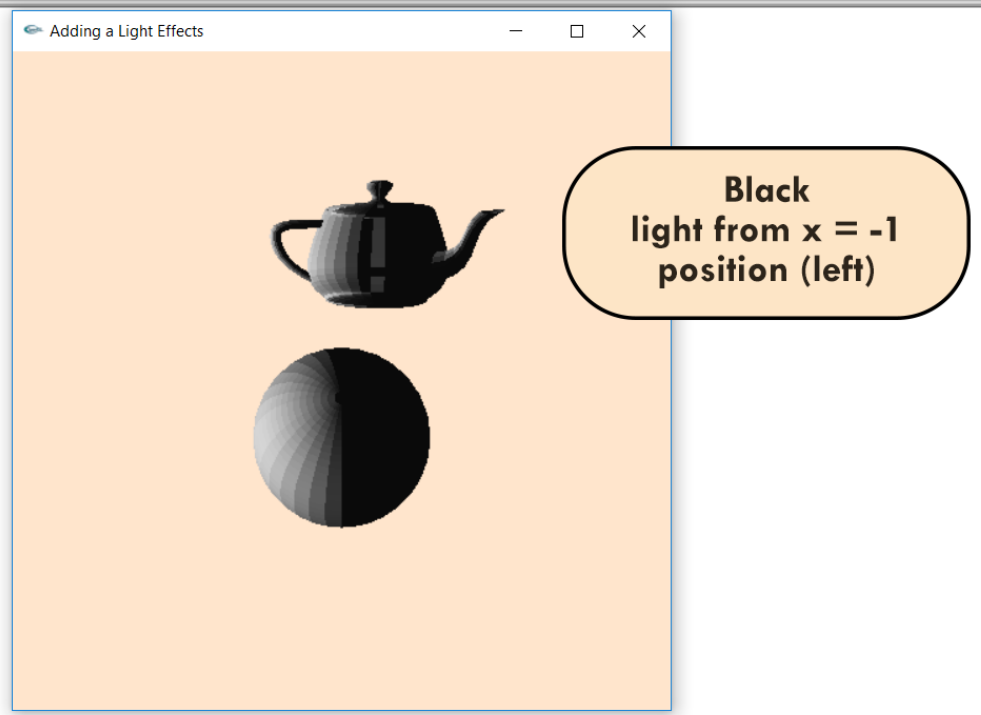

A Lighting Program Using OpenGL

Code::Blocks 17.12

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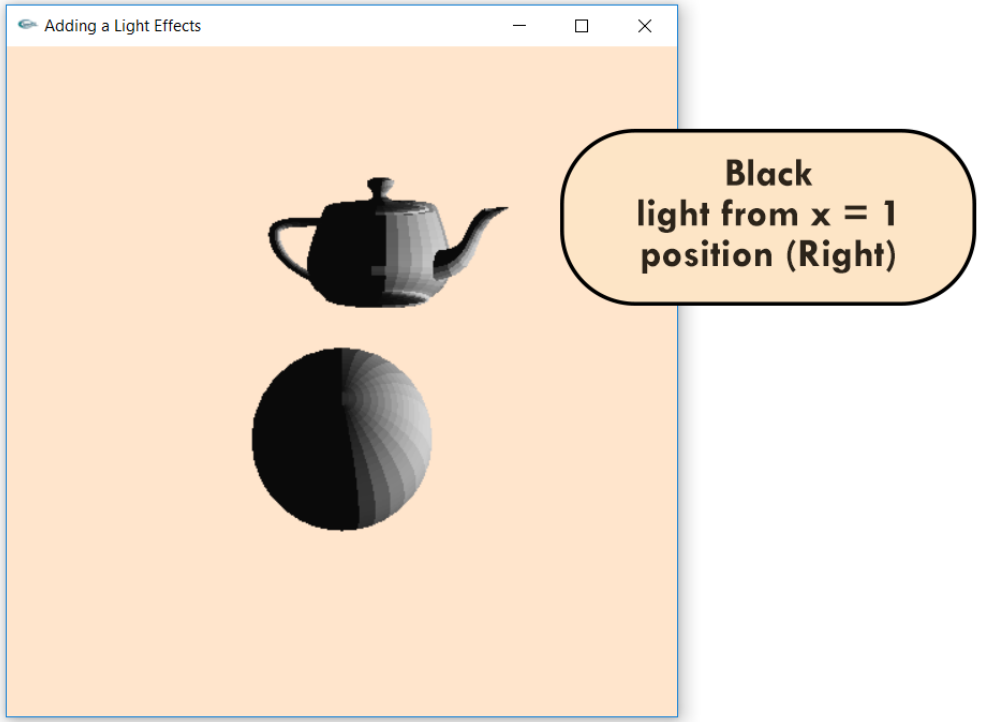
Lighting.cpp

```
#include<windows.h>
#include<GL/glut.h>
void Draw() {
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
    //Lighting Part
    GLfloat mat_specular[] = {0, 0, 0, 0};
    GLfloat light_position[] = {1, 0, 0, 0};
    glMaterialfv(GL_FRONT, GL_SPECULAR, mat_specular);
    glLightfv(GL_LIGHT0, GL_POSITION, light_position);
    glEnable(GL_LIGHTING);
    glEnable(GL_LIGHT0);
    //Ending of the Lighting Part
    glColor3f(1.0, 1.0, 1.0);
    glutSolidSphere(1.5, 30, 30);
    glTranslatef(0.5, 3, 0.0);
    glColor3f(0,0,0);
    glutSolidTeapot(1);
    glFlush(); }
void init() {
    glClearColor(1, 0.9, 0.8, 0.0);
    glShadeModel(GL_FLAT);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-1, 1, -1, 1, 1, 15);
    glMatrixMode(GL_MODELVIEW); }
int main() {
    glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize (500, 500);
    glutInitWindowPosition(0,0);
    glutCreateWindow("Adding a Light Effects");
    init();
    glutDisplayFunc(Draw);
    glutMainLoop();
    return 0; }
```



A Lighting Program Using OpenGL

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Debug

Lighting.cpp

```
#include<windows.h>
#include<GL/glut.h>
void Draw() {
    glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
    gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
    //Lighting Part
    GLfloat mat_specular[] = {1, 0.5, 0.5, 0};
    GLfloat light_position[] = {1, 1, 0, 0};
    glMaterialfv(GL_FRONT, GL_SPECULAR, mat_specular);
    glLightfv(GL_LIGHT0, GL_POSITION, light_position);
    glEnable(GL_LIGHTING);
    glEnable(GL_LIGHT0);
    //Ending of the Lighting Part
    glColor3f(1.0, 1.0, 1.0);
    glutSolidSphere(1.5, 30, 30);
    glTranslatef(0.5, 3, 0.0);
    glColor3f(0,0,0);
    glutSolidTeapot(1);
    glFlush(); }
void init() {
    glClearColor(1, 0.9, 0.8, 0.0);
    glShadeModel(GL_FLAT);
    glMatrixMode(GL_PROJECTION);
    glLoadIdentity();
    glFrustum(-1, 1, -1, 1, 1, 15);
    glMatrixMode(GL_MODELVIEW); }
int main() {
    glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB);
    glutInitWindowSize (500, 500);
    glutInitWindowPosition(0,0);
    glutCreateWindow("Adding a Light Effects");
    init();
    glutDisplayFunc(Draw);
    glutMainLoop();
    return 0; }
```

A Lighting Program Using OpenGL

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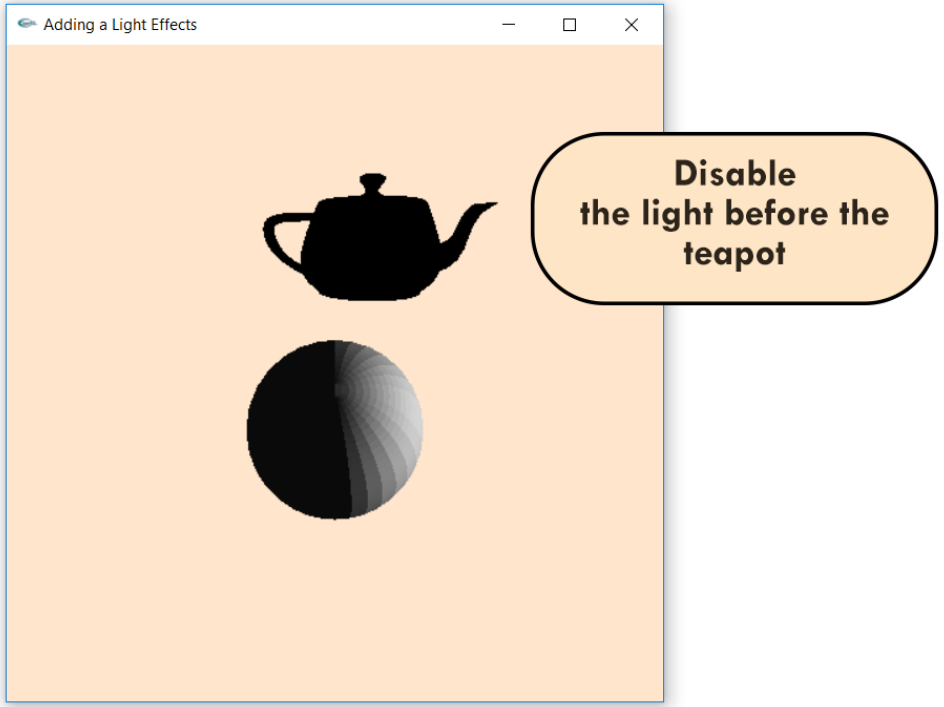
Lighting.cpp

```
1  #include<windows.h>
2  #include<GL/glut.h>
3  void Draw() {
4      glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
5      gluLookAt(0, 3, 5, 0, 1, 0, 0, 1, 2);
6      //Lighting Part
7      GLfloat mat_specular[] = {0, 0, 0, 0};
8      GLfloat light_position[] = {1, 0, 0, 0};
9      glMaterialfv(GL_FRONT, GL_SPECULAR, mat_specular);
10     glLightfv(GL_LIGHT0, GL_POSITION, light_position);
11     glEnable(GL_LIGHTING);
12     glEnable(GL_LIGHT0);
13     //Ending of the Lighting Part
14     glColor3f(1.0, 1.0, 1.0);
15     glutSolidSphere(1.5, 30, 30);
16     glDisable(GL_LIGHTING);
17     glTranslatef(0.5, 3, 0.0);
18     glColor3f(0,0,0);
19     glutSolidTeapot(1);
20     glFlush(); }
21 void init() {
22     glClearColor(1, 0.9, 0.8, 0.0);
23     glShadeModel(GL_FLAT);
24     glMatrixMode(GL_PROJECTION);
25     glLoadIdentity();
26     glFrustum(-1, 1, -1, 1, 1, 15);
27     glMatrixMode(GL_MODELVIEW); }
28 int main() {
29     glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB);
30     glutInitWindowSize (500, 500);
31     glutInitWindowPosition(0,0);
32     glutCreateWindow("Adding a Light Effects");
33     init();
34     glutDisplayFunc(Draw);
35     glutMainLoop();
36     return 0; }
37
```



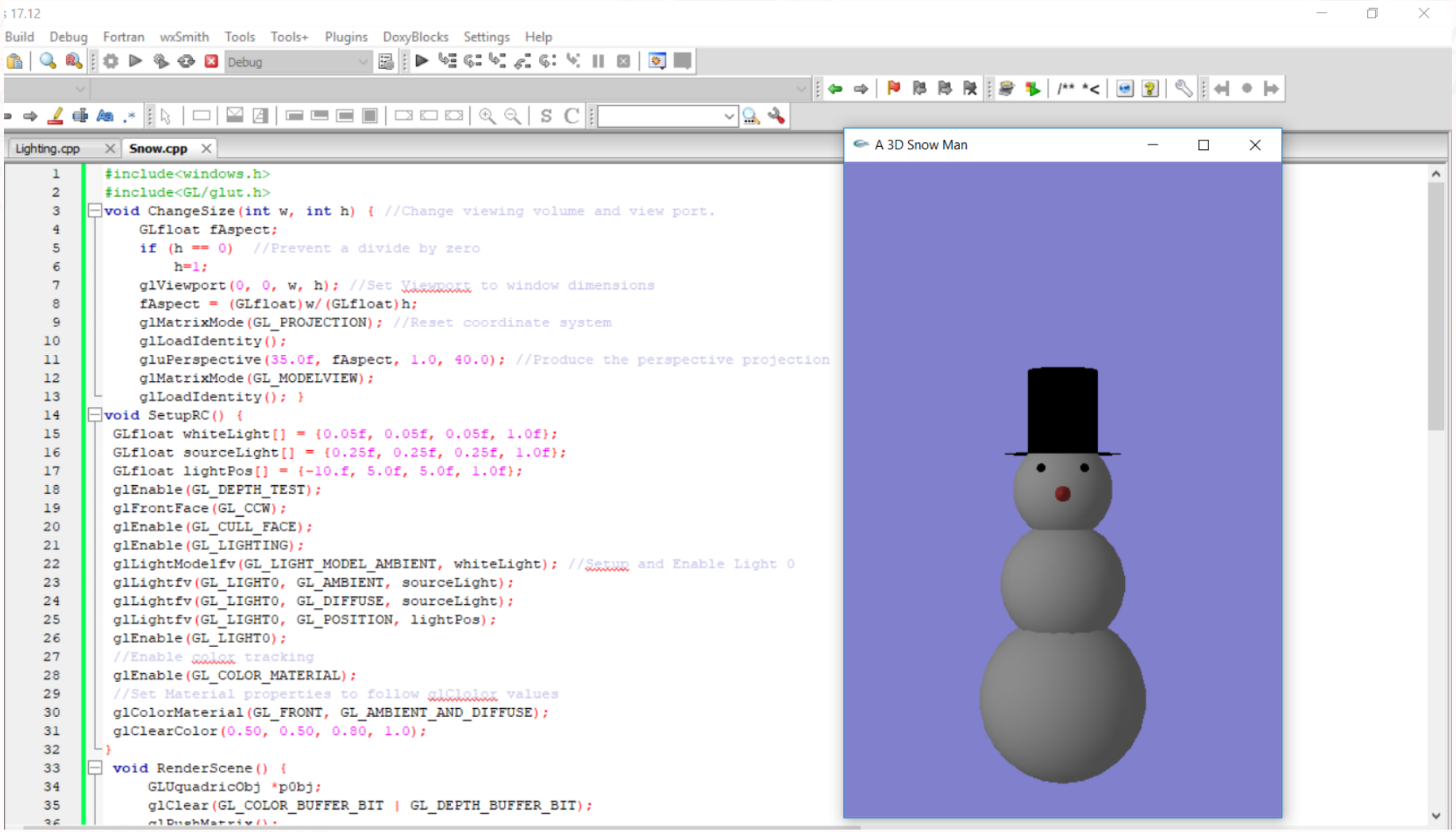
A Snow Man Program Using OpenGL

```
#include<windows.h>
#include<GL/glut.h>
void ChangeSize(int w, int h) { //Change viewing volume and view port.
    GLfloat fAspect;
    if (h == 0)  //Prevent a divide by zero
        h=1;
    glViewport(0, 0, w, h); //Set Viewport to window dimensions
    fAspect = (GLfloat)w/(GLfloat)h;
    glMatrixMode(GL_PROJECTION); //Reset coordinate system
    glLoadIdentity();
    gluPerspective(35.0f, fAspect, 1.0, 40.0); //Produce the perspective projection
    glMatrixMode(GL_MODELVIEW);
    glLoadIdentity(); }
void SetupRC() {
 GLfloat whiteLight[] = {0.05f, 0.05f, 0.05f, 1.0f};
 GLfloat sourceLight[] = {0.25f, 0.25f, 0.25f, 1.0f};
 GLfloat lightPos[] = {-10.f, 5.0f, 5.0f, 1.0f};
 glEnable(GL_DEPTH_TEST);
 glFrontFace(GL_CCW);
 glEnable(GL_CULL_FACE);
 glEnable(GL_LIGHTING);
 glLightModelfv(GL_LIGHT_MODEL_AMBIENT, whiteLight); //Setup and Enable Light 0
 glLightfv(GL_LIGHT0, GL_AMBIENT, sourceLight);
 glLightfv(GL_LIGHT0, GL_DIFFUSE, sourceLight);
 glLightfv(GL_LIGHT0, GL_POSITION, lightPos);
 glEnable(GL_LIGHT0);
 //Enable color tracking
 glEnable(GL_COLOR_MATERIAL);
 //Set Material properties to follow glClolor values
 glColorMaterial(GL_FRONT, GL_AMBIENT_AND_DIFFUSE);
 glClearColor(0.50, 0.50, 0.80, 1.0);
}
```

A Snow Man Program Using OpenGL

```
void RenderScene() {
     GLUquadricObj *p0bj;
     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
     glPushMatrix();
     glTranslatef(0, -1, -5);
     glRotatef(0, 1, 0, 0);
     glRotatef(0, 0, 1, 0);
     //Draw something
    p0bj = gluNewQuadric();
    gluQuadricNormals(p0bj, GLU_SMOOTH);
    //Main Body
    glPushMatrix();
    glColor3f(1,1,1);
    gluSphere(p0bj, 0.40, 26, 13); //Bottom
    glTranslatef(0, 0.55, 0); //Mid Section
    gluSphere(p0bj, 0.3, 26, 13);
    glTranslatef(0, 0.45, 0); //Head
    gluSphere(p0bj, 0.24, 26, 13);
    //Eyes
    glColor3f(0,0,0);
    glTranslatef(0.1, 0.1, 0.21);
    gluSphere(p0bj, 0.02, 26, 13);
    glTranslatef(-0.2, 0, 0);
    gluSphere(p0bj, 0.02, 26, 13);
    //Nose
    glColor3f(1.0, 0.3, 0.3);
    glTranslatef(0.1, -0.12, 0.0);
    gluCylinder(p0bj, 0.04, 0, 0.3, 26, 13);
    glPopMatrix();
    //Hat
    glPushMatrix();
    glColor3f(0,0,0);
    glTranslatef(0, 1.17, 0);
    glRotatef(-90.0f, 1, 0, 0);
    gluCylinder(p0bj, 0.17, 0.17, 0.4, 26, 13);
    //Hat brim
    glDisable(GL_CULL_FACE);
    gluDisk(p0bj, 0.17f, 0.28, 26, 13);
    glEnable(GL_CULL_FACE);
    glTranslatef(0.0f, 0.0f, 0.40f);
    gluDisk(p0bj, 0.0f, 0.17f, 26, 13);
    glPopMatrix();
    //Restore the Matrix State
    glPopMatrix();
    //Buffer swap
    glutSwapBuffers(); }
int main() {
    glutInitDisplayMode(GLUT_DOUBLE | GLUT_RGB| GLUT_DEPTH);
    glutInitWindowSize(400, 600);
    glutInitWindowPosition(0,0);
    glutCreateWindow("A 3D Snow Man");
    glutReshapeFunc(ChangeSize);
    glutDisplayFunc(RenderScene);
    SetupRC();
    glutMainLoop();
return 0; }
```

A Snow Man Program Using OpenGL




```
#include<windows.h>
#include<GL/glut.h>
void ChangeSize(int w, int h) { //Change viewing volume and view port.
    GLfloat fAspect;
    if (h == 0)  //Prevent a divide by zero
        h=1;
    glViewport(0, 0, w, h); //Set Viewport to window dimensions
    fAspect = (GLfloat)w/(GLfloat)h;
    glMatrixMode(GL_PROJECTION); //Reset coordinate system
    glLoadIdentity();
    gluPerspective(35.0f, fAspect, 1.0, 40.0); //Produce the perspective projection
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void SetupRC() {
 GLfloat whiteLight[] = {0.05f, 0.05f, 0.05f, 1.0f};
 GLfloat sourceLight[] = {0.25f, 0.25f, 0.25f, 1.0f};
 GLfloat lightPos[] = {-10.f, 5.0f, 5.0f, 1.0f};
 glEnable(GL_DEPTH_TEST);
 glFrontFace(GL_CCW);
 glEnable(GL_CULL_FACE);
 glEnable(GL_LIGHTING);
 glLightModelfv(GL_LIGHT_MODEL_AMBIENT, whiteLight); //Setup and Enable Light 0
 glLightfv(GL_LIGHT0, GL_AMBIENT, sourceLight);
 glLightfv(GL_LIGHT0, GL_DIFFUSE, sourceLight);
 glLightfv(GL_LIGHT0, GL_POSITION, lightPos);
 glEnable(GL_LIGHT0);
 //Enable color tracking
 glEnable(GL_COLOR_MATERIAL);
 //Set Material properties to follow glColor values
 glColorMaterial(GL_FRONT, GL_AMBIENT_AND_DIFFUSE);
 glClearColor(0.50, 0.50, 0.80, 1.0);
}
 void RenderScene() {
     GLUquadricObj *pObj;
     glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
```
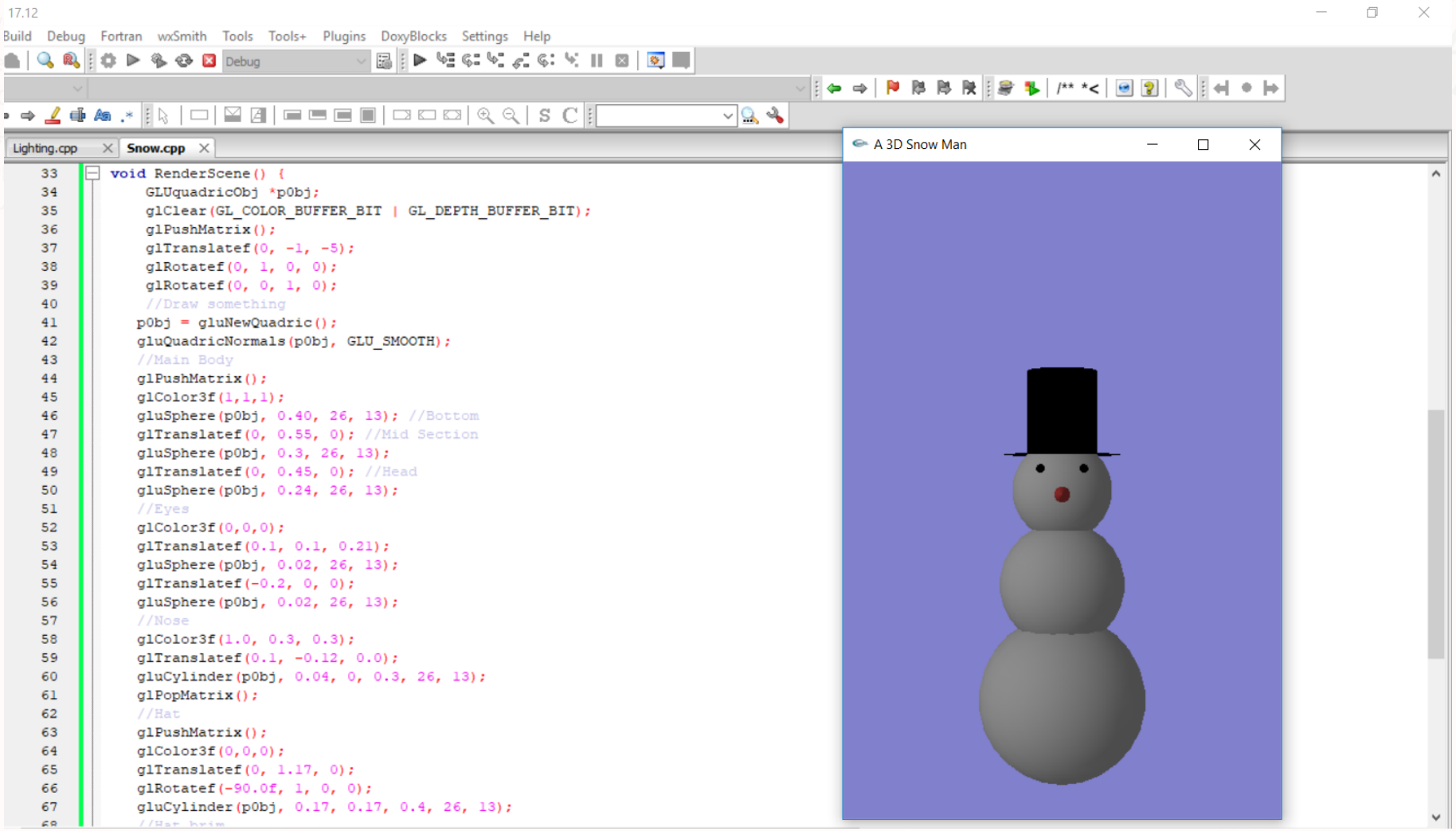
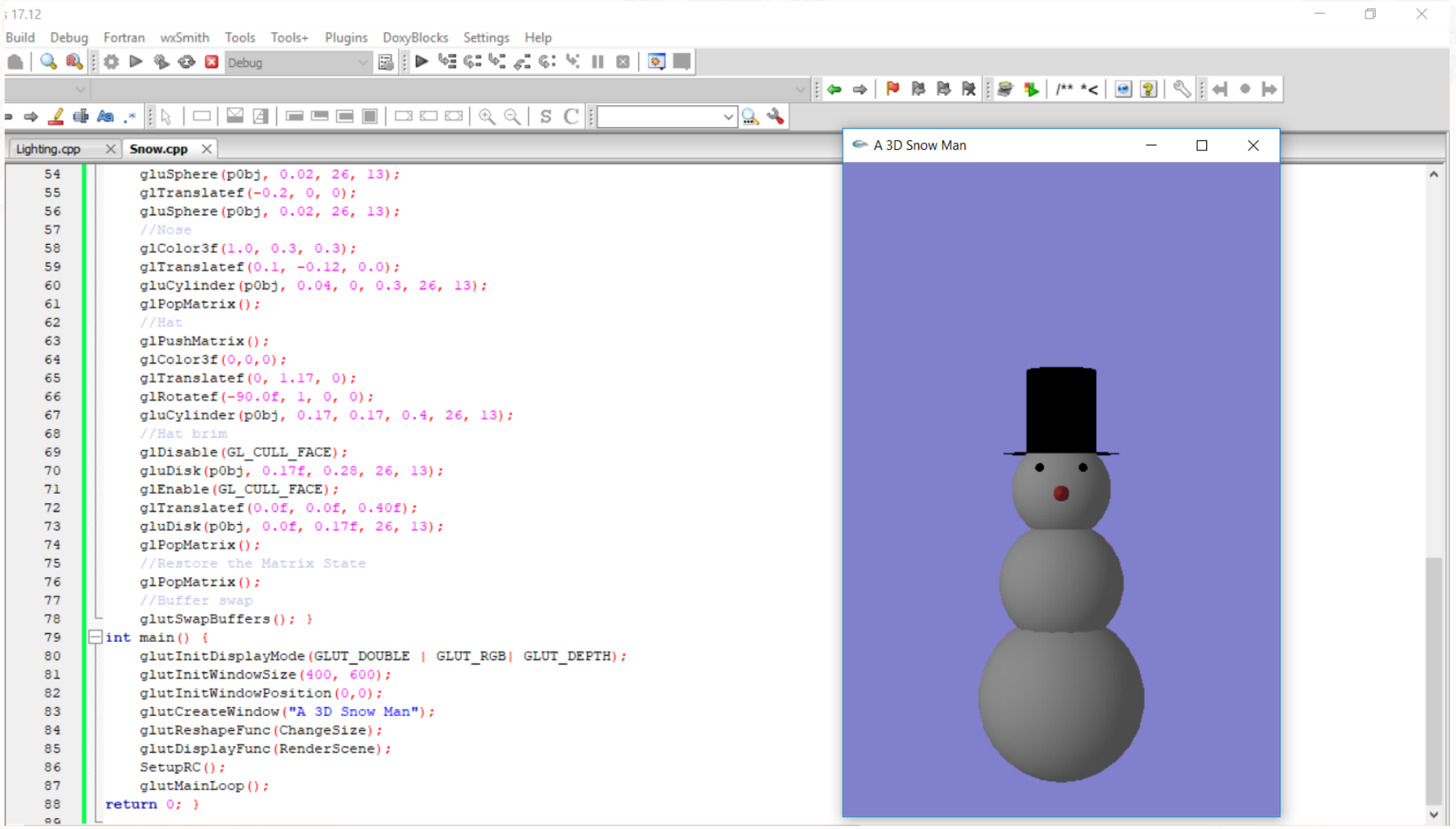

A Snow Man Program Using OpenGL




```
33  void RenderScene() {
34      GLUquadricObj *p0bj;
35      glClear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT);
36      glPushMatrix();
37      glTranslatef(0, -1, -5);
38      glRotatef(0, 1, 0, 0);
39      glRotatef(0, 0, 1, 0);
40      //Draw something
41     p0bj = gluNewQuadric();
42     gluQuadricNormals(p0bj, GLU_SMOOTH);
43     //Main Body
44     glPushMatrix();
45     glColor3f(1,1,1);
46     gluSphere(p0bj, 0.40, 26, 13); //Bottom
47     glTranslatef(0, 0.55, 0); //Mid Section
48     gluSphere(p0bj, 0.3, 26, 13);
49     glTranslatef(0, 0.45, 0); //Head
50     gluSphere(p0bj, 0.24, 26, 13);
51     //Eyes
52     glColor3f(0,0,0);
53     glTranslatef(0.1, 0.1, 0.21);
54     gluSphere(p0bj, 0.02, 26, 13);
55     glTranslatef(-0.2, 0, 0);
56     gluSphere(p0bj, 0.02, 26, 13);
57     //Nose
58     glColor3f(1.0, 0.3, 0.3);
59     glTranslatef(0.1, -0.12, 0.0);
60     gluCylinder(p0bj, 0.04, 0, 0.3, 26, 13);
61     glPopMatrix();
62     //Hat
63     glPushMatrix();
64     glColor3f(0,0,0);
65     glTranslatef(0, 1.17, 0);
66     glRotatef(-90.0f, 1, 0, 0);
67     gluCylinder(p0bj, 0.17, 0.17, 0.4, 26, 13);
```

A Snow Man Program Using OpenGL



وصلى الله وبارك على نبينا محمد

The End Summary of Lecture Nine

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