

Ballwall

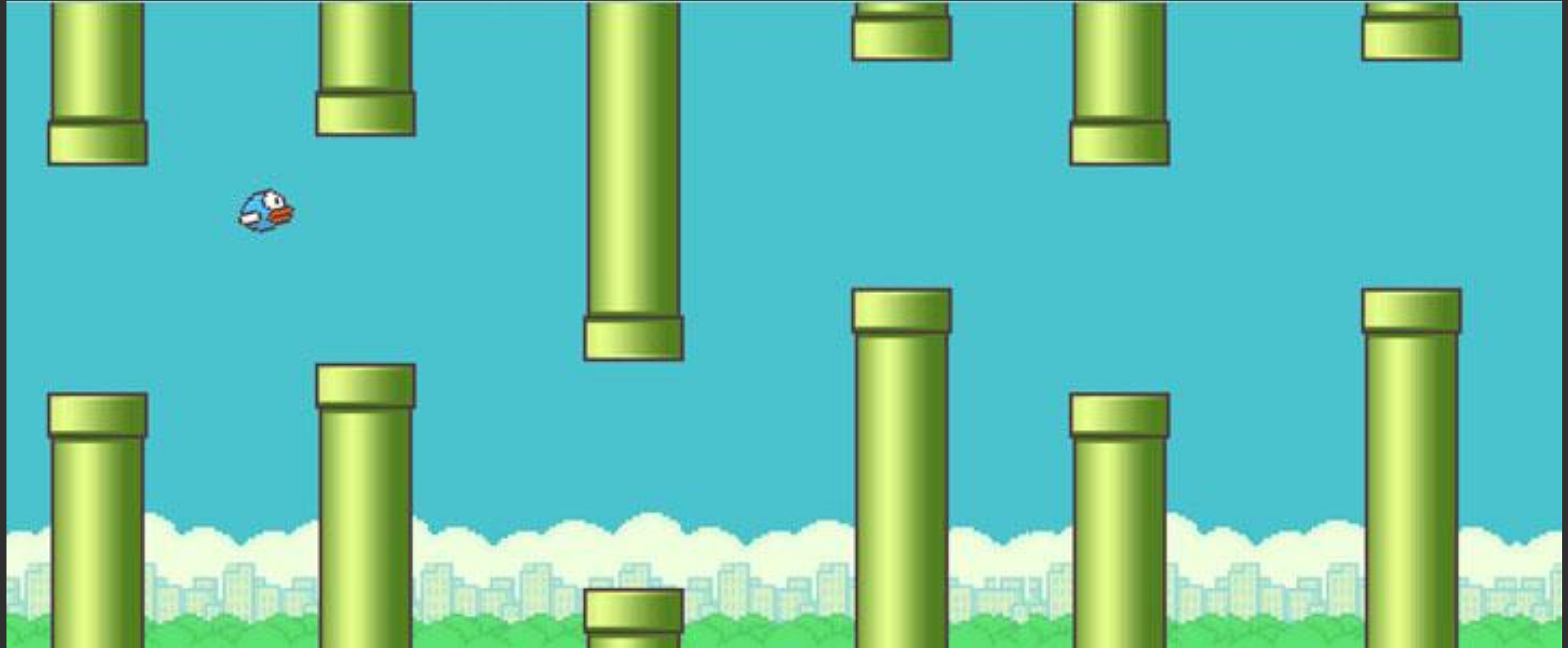
„3D – Flappy Bird“

Samardzic Nuris, 01611855

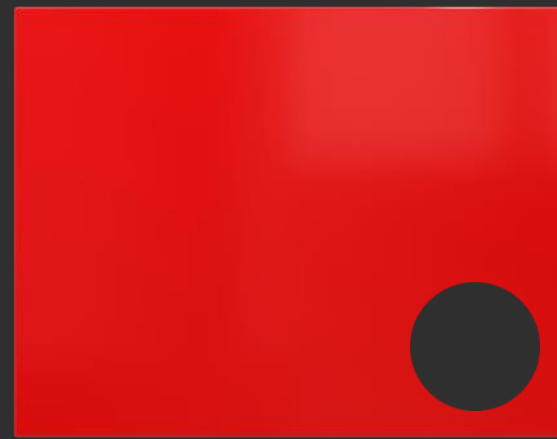
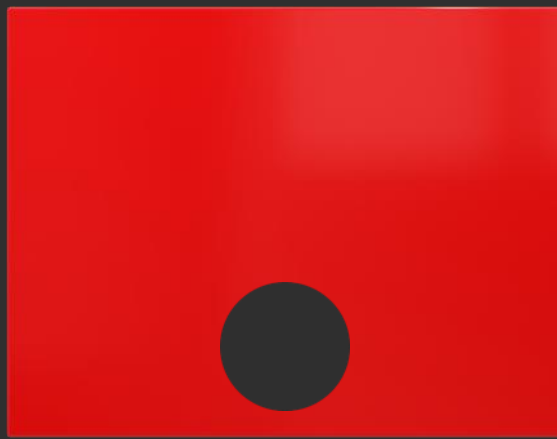
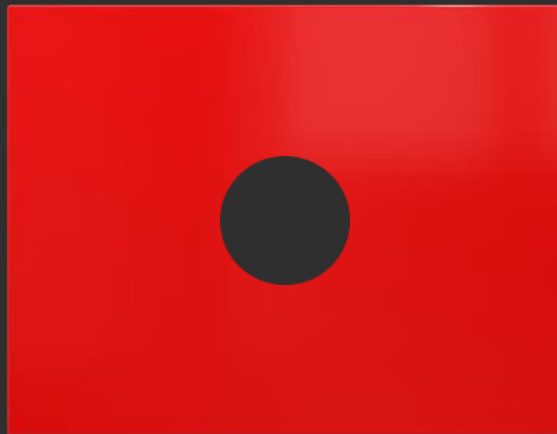
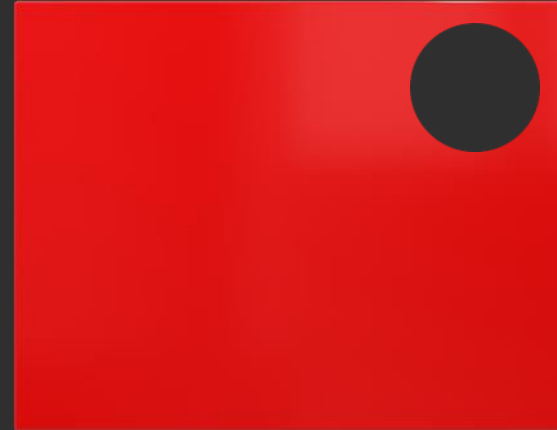
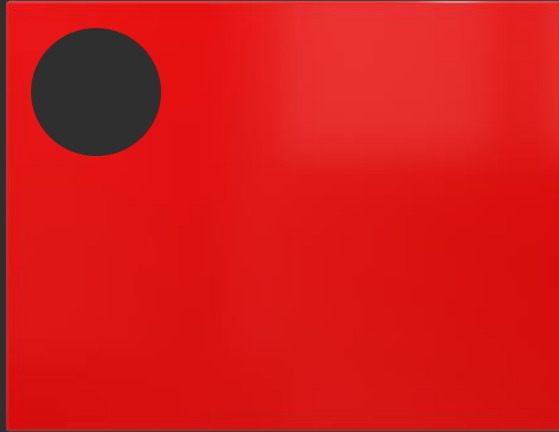
Tosun Begüm, 11719058

Contents

- Basic Idea
- Libraries
- Code







Demo

Libraries

- OpenGL extensions: implementations to provide new or expanded functionality that the core of OpenGL does not provide
- glew v2.2.0 OpenGL Extension Wrangler Library (GLEW) :
 - a cross-platform open-source C/C++ extension loading library
 - provides efficient run-time mechanisms for determining which OpenGL extensions are supported on the target platform
 - currently maintained by Nigel Stewart with bug fixes, new OpenGL extension support and new releases
 - was developed by Milan Ikits and Marcelo Magallon
 - Aaron Lefohn, Joe Kniss, and Chris Wyman were the first users and also assisted with the design and debugging process

Libraries

- freeglut v3.0.0 free GL Utility Toolkit:
 - GLUT vs freeglut:
 - GLUT is getting old and really needs improvement
 - its license does not allow anyone to distribute modified library code
- freeglut is a free-software/open-source alternative to the GLUT library
- originally written by Pawel W. Olszta with contributions from Andreas Umbach and Steve Baker
- John F. Fay, John Tsiombikas, and Diederick C. Niehorster are the current maintainers of the freeglut project


```

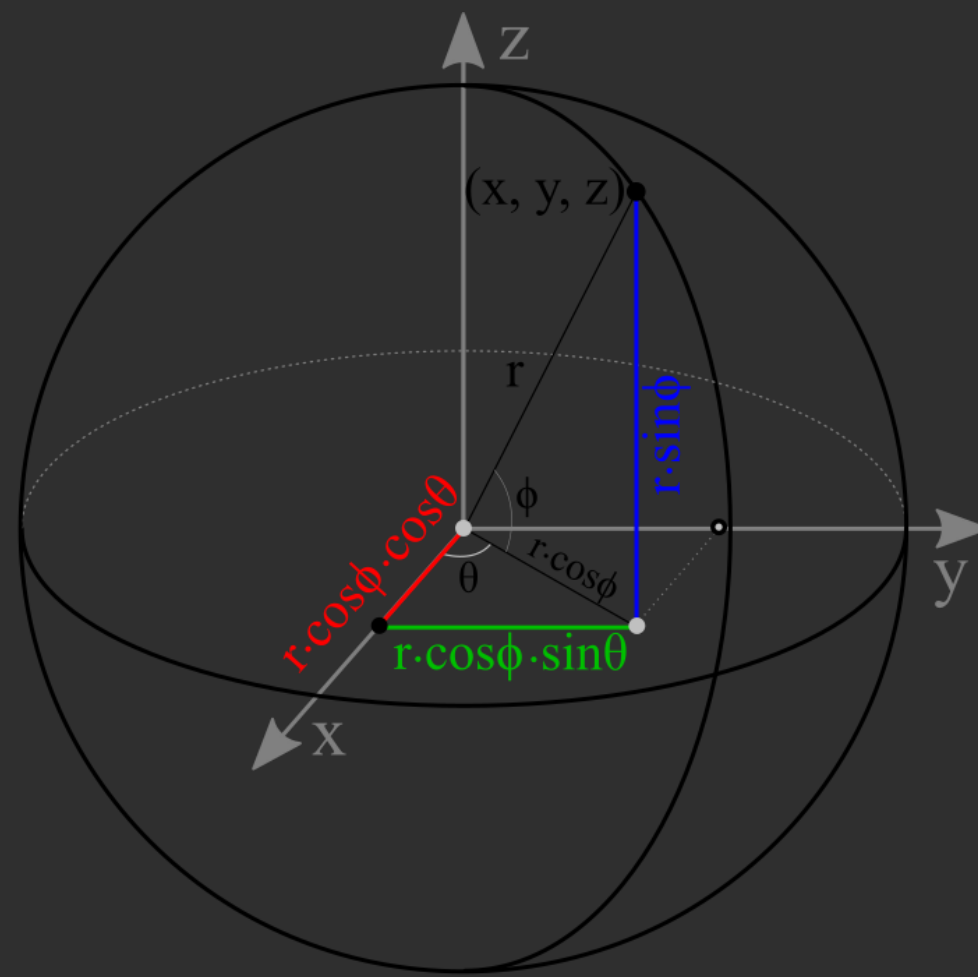
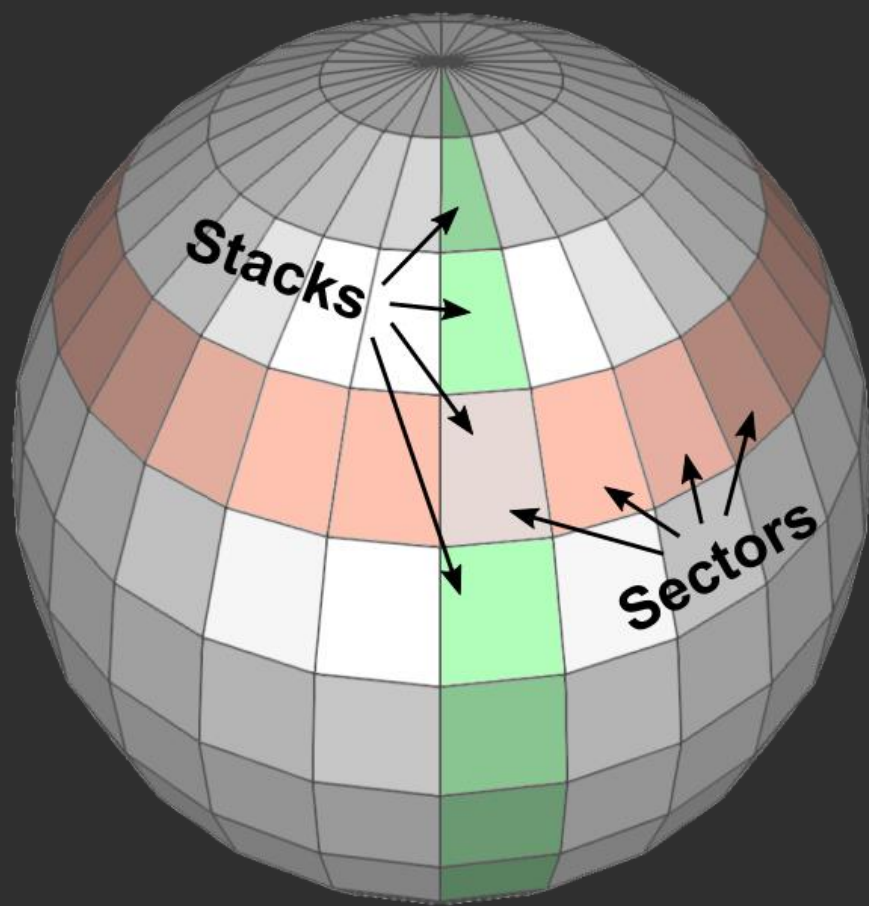
54     #define zwallinit 25.0f
55     // set wall parameters
56     void nextwall() {
57         walltype = rand()%9; // wall type
58         zwall = -zwallinit; // initial z position
59         holex = (walltype%3 - 1)*holedist; // x coordinate of the hole center
60         holey = (walltype/3 - 1)*holedist; // y coordinate of the hole center
61         // saturated color:
62         int i = rand()%3, j = rand()%2;
63         wallcolor[i] = 1.0f;
64         wallcolor[(1 + i + j)%3] = 0.0f;
65         // wallcolor[(1 + i + !j)%3] = (float)rand()/RAND_MAX;
66         wallcolor[(1 + i + !j)%3] = (rand()%5)*0.25f;
67     }

```

Creating walls

Sphere

- 3D closed surface where every point on the sphere is same distance (radius) from a given point
- $x^2 + y^2 + z^2 = r^2$
- we cannot draw all the points on a sphere
- sample a limited amount of points by dividing the sphere by sectors and stacks
- an arbitrary point (x, y, z) on a sphere can be computed with the corresponding sector angle θ and stack angle ϕ
- $$\begin{aligned}x &= (r \cdot \cos \phi) \cdot \cos \theta & z &= r \cdot \sin \phi \\ y &= (r \cdot \cos \phi) \cdot \sin \theta\end{aligned}$$



Sphere

- range of sector angles is from 0 to 360 degrees
- stack angles are from 90 (top) to -90 degrees (bottom)



$$\theta = 2\pi \cdot \frac{\text{sectorStep}}{\text{sectorCount}}$$

$$\phi = \frac{\pi}{2} - \pi \cdot \frac{\text{stackStep}}{\text{stackCount}}$$

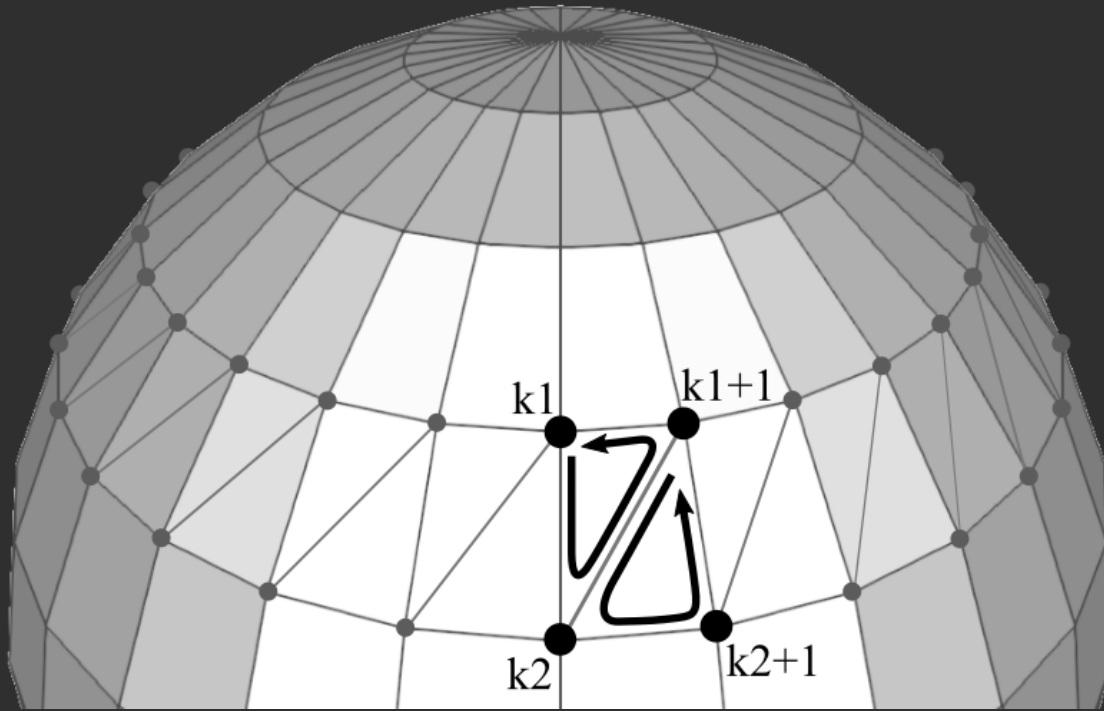
Creating the sphere

- adapted from http://www.songho.ca/opengl/gl_sphere.html
- done in three main steps

Creating the sphere: 1.step

```
271 for(int i = 0; i <= stackCount; ++i)
272 {
273     stackAngle = Pi / 2 - i * stackStep;           // starting from pi/2 to -pi/2
274     xy = radius * cosf(stackAngle);                 // r * cos(u)
275     z = radius * sinf(stackAngle);                 // r * sin(u)
276
277     // add (sectorCount+1) vertices per stack
278     // the first and last vertices have same position and normal, but different tex coords
279     for(int j = 0; j <= sectorCount; ++j)
280     {
281         sectorAngle = j * sectorStep;               // starting from 0 to 2pi
282
283         // vertex position (x, y, z)
284         x = xy * cosf(sectorAngle);                 // r * cos(u) * cos(v)
285         y = xy * sinf(sectorAngle);                 // r * cos(u) * sin(v)
286         vnbuffer2.push_back(x);
287         vnbuffer2.push_back(y);
288         vnbuffer2.push_back(z);
289
290         // normalized vertex normal (nx, ny, nz)
291         nx = x * lengthInv;
292         ny = y * lengthInv;
293         nz = z * lengthInv;
294         vnbuffer2.push_back(nx);
295         vnbuffer2.push_back(ny);
296         vnbuffer2.push_back(nz);
297     }
298 }
```

Sphere



- to draw the surface of a sphere in OpenGL, you must triangulate adjacent vertices to form polygons
- Each sector in a stack requires 2 triangles
- If the first vertex index in the current stack is $k1$ and the next stack is $k2$, then the counterclockwise orders of vertex indices of 2 triangles are;
 - $k1 \rightarrow k2 \rightarrow k1+1$
 - $k1+1 \rightarrow k2 \rightarrow k2+1$

Creating the sphere: 2.step

```
306   for(int i = 0; i < stackCount; ++i)
307   {
308       k1 = i * (sectorCount + 1);    // beginning of current stack
309       k2 = k1 + sectorCount + 1;    // beginning of next stack
310
311       for(int j = 0; j < sectorCount; ++j, ++k1, ++k2)
312       {
313           // 2 triangles per sector excluding first and last stacks
314           // k1 => k2 => k1+1
315           if(i != 0)
316           {
317               indices.push_back(k1);
318               indices.push_back(k2);
319               indices.push_back(k1 + 1);
320           }
321
322           // k1+1 => k2 => k2+1
323           if(i != (stackCount-1))
324           {
325               indices.push_back(k1 + 1);
326               indices.push_back(k2);
327               indices.push_back(k2 + 1);
328           }
329       }
330   }
```



```

331     GLuint VBO, EBO;
332     glGenVertexArrays(1, &sphereId); // generate the vertex array index for the sphere
333     glGenBuffers(1, &VBO); // generate a vertex buffer
334     glGenBuffers(1, &EBO); // generate a index buffer
335     glBindVertexArray(sphereId); // bind the sphere id
336     glBindBuffer(GL_ARRAY_BUFFER, VBO); // bind the vertex buffer
337     // fill the vertex buffer
338     glBufferData(GL_ARRAY_BUFFER, vnbuffer2.size()*sizeof(float), &vnbuffer2[0], GL_STATIC_DRAW);
339     glBindBuffer(GL_ELEMENT_ARRAY_BUFFER, EBO); // bind the index buffer
340     NumSphereIndices = (int)indices.size();
341     // fill the index buffer
342     glBufferData(GL_ELEMENT_ARRAY_BUFFER, NumSphereIndices*sizeof(float), &indices[0], GL_STATIC_DRAW);
343     // specify the location and data format of the vertex buffer array
344     glVertexAttribPointer(0, 3, GL_FLOAT, GL_FALSE, 6*sizeof(GLfloat), (void*)0);
345     glEnableVertexAttribArray(0);
346     glVertexAttribPointer(1, 3, GL_FLOAT, GL_FALSE, 6*sizeof(GLfloat), (void*)(3*sizeof(GLfloat)));
347     glEnableVertexAttribArray(1);
348     glBindBuffer(GL_ARRAY_BUFFER, 0);
349     glBindVertexArray(0); // unbind the sphere id

```

Creating the sphere: 3.step

```

23 // set the projection matrix (Mp)
24 void camera::perspective(double fovy, double ratiohw, double cnear, double cfar) {
25     double _t = 1/tan(fovy*(M_PI/360)); // tan of half fovy
26     Mp[0][0] = ratiohw*_t;
27     Mp[1][1] = _t;
28     Mp[2][2] = (cfar + cnear)/(cnear - cfar);
29     Mp[2][3] = 2*cfar*cnear/(cnear - cfar);
30     Mp[3][2] = -1;
31     Mp[0][1] = Mp[0][2] = Mp[0][3] = Mp[1][0] = 0;
32     Mp[1][2] = Mp[1][3] = Mp[2][0] = Mp[2][1] = 0;
33     Mp[3][0] = Mp[3][1] = Mp[3][3] = 0;
34 }
35
36
37 void camera::LookAt(double x, double y, double z, double cx, double cy, double cz, double ux, double uy, double uz) {
38     double u[3] = {ux, uy, uz};
39     pos[0] = x; pos[1] = y; pos[2] = z;
40     fwd[0] = cx - x; fwd[1] = cy - y; fwd[2] = cz - z;
41     normalize3d(fwd);
42     crossproduct(right, fwd, u);
43     normalize3d(right);
44     crossproduct(up, right, fwd);
45     calcMatrixModelView();
46 }

```

Perspective / View

Perspective / View

```
64  void camera::calcMatrixModelViewProjection() {  
65      for (int j = 0; j != 4; j++)  
66      for (int i = 0; i != 4; i++) {  
67          Mvp[j][i] = 0;  
68          for (int k = 0; k != 4; k++)  
69              Mvp[j][i] += Mp[j][k]*Mv[k][i];  
70      }  
71  }
```

Shaders

```
1  #version 330 compatibility
2  // adapted from the shader code in main.cpp file,
3  http://www.songho.ca/opengl/files/sphereShader.zip
4  layout (location = 0) in vec3 vertexPosition;
5  layout (location = 1) in vec3 vertexNormal;
6
7  uniform mat4 matrixModelViewProjection;
8  uniform mat4 matrixModelView;
9  uniform mat3 matrixNormal;
10 uniform vec3 displacement;
11
12 out vec3 esVertex, esNormal;
13 out float z;
14
15 void main()
16 {
17     vec4 newposition = vec4(vertexPosition + displacement, 1.0);
18     esVertex = vec3(matrixModelView * newposition);
19     esNormal = matrixNormal * vertexNormal;
20     z = -newposition.z;
21     gl_Position = matrixModelViewProjection * newposition;
22 }
23
```

Shaders

```
1 #version 330 compatibility
2 // adapted from the shader code in main.cpp file, http://www.songho.ca/opengl/files/sphereShader.zip
3
4 uniform vec4 lightPosition;           // should be in the eye space
5 uniform vec4 lightAmbient;           // light ambient color
6 uniform vec4 lightDiffuse;           // light diffuse color
7 uniform vec4 lightSpecular;          // light specular color
8 uniform vec4 materialColor;          // material ambient and diffuse color
9 uniform vec4 materialSpecular;       // material specular color
10 uniform float materialShininess;     // material specular shininess
11
12 in vec3 esVertex, esNormal;
13 in float z;
14
15 out vec4 vFragColor;
16
17 void main()
18 {
19     vec3 normal = normalize(esNormal);
20     vec3 light;
21     if(lightPosition.w == 0.0)
22     {
23         light = normalize(lightPosition.xyz);
24     }
25     else
26     {
27         light = normalize(lightPosition.xyz - esVertex);
28     }
29     vec3 view = normalize(-esVertex);
30     vec3 halfv = normalize(light + view);
31
32     vec3 color = lightAmbient.rgb * materialColor.rgb;           // begin with ambient
33     float dotNL = max(dot(normal, light), 0.0);
34
35     color += lightDiffuse.rgb * materialColor.rgb * dotNL;      // add diffuse
36     float dotNH = max(dot(normal, halfv), 0.0);
37     color += pow(dotNH, materialShininess) * lightSpecular.rgb * materialSpecular.rgb; // add specular
38
39     vec3 fogColor = vec3(0.0, 0.0, 0.0);
40     color = mix(color, fogColor, smoothstep(-8.0, 27.0, z));
41
42     // set frag color
43     vFragColor = vec4(color, materialColor.a);
44 }
45
```