Modeler Help

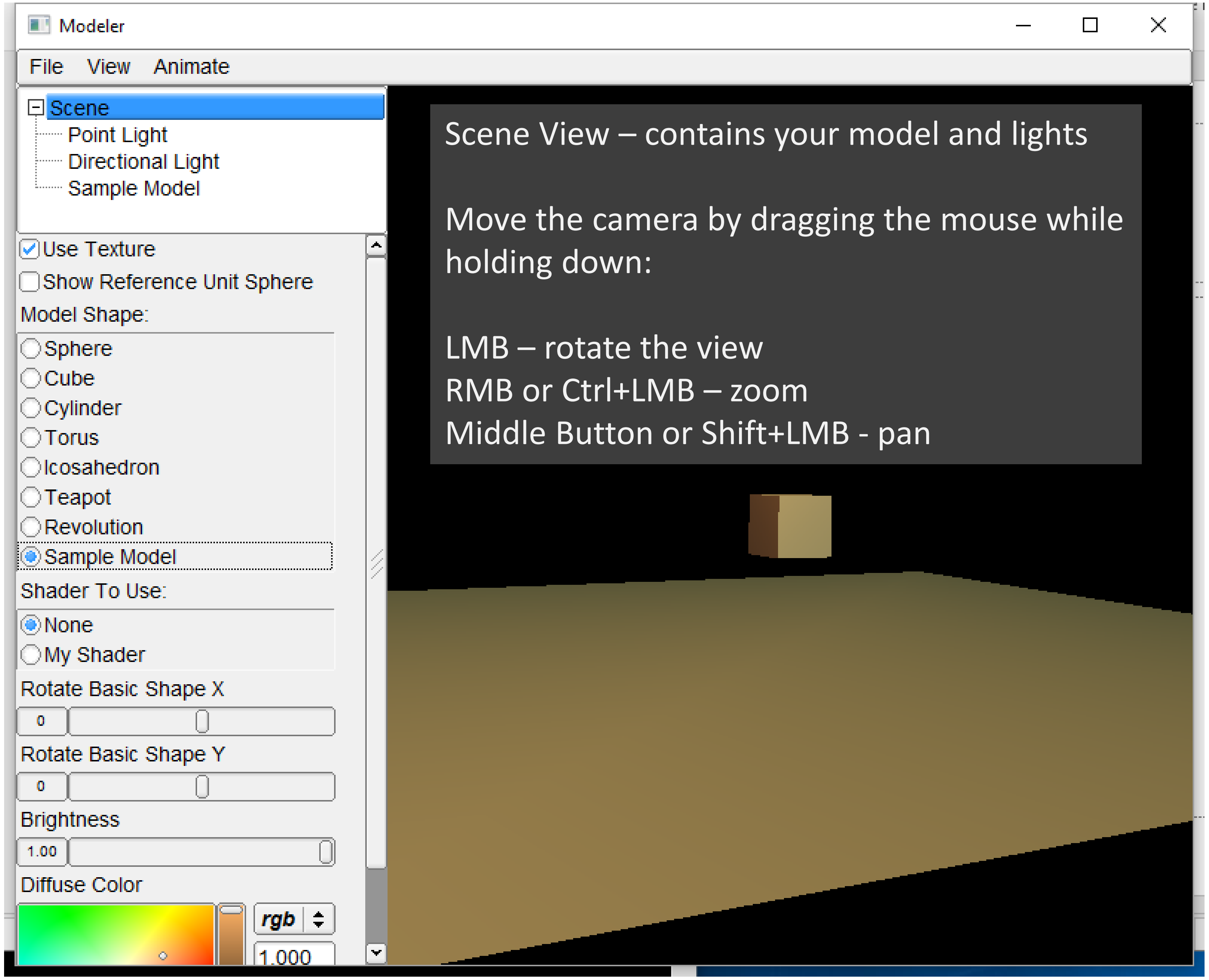
Outline

- Introduction
- Surface of Revolution
- Hierarchical Modeling
- Blinn-Phong Shader
- Custom Shader(s)

Objects in the Scene

Controls of the object selected in the Scene.

Currently the Scene itself is selected.



[✓ Use Texture]

Show Reference Unit Sphere

Model Shape:

Sphere
Cube
Cylinder
Torus
Icosahedron
Teapot
Revolution
[✓ Sample Model]

Shader To Use:

[✓ None]
My Shader

Rotate Basic Shape X: 0

Rotate Basic Shape Y: 0

Brightness: 1.00

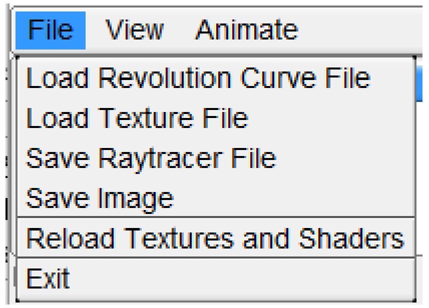
Diffuse Color: 1.000

Scene View – contains your model and lights

Move the camera by dragging the mouse while holding down:

LMB – rotate the view
RMB or Ctrl+LMB – zoom
Middle Button or Shift+LMB - pan

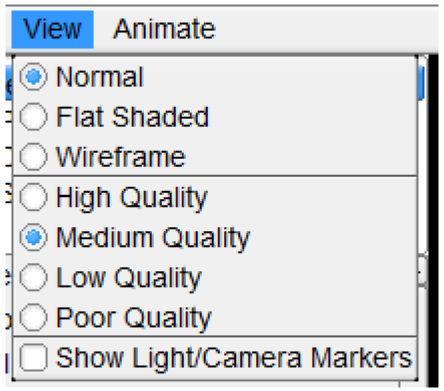
Menu Options



Load Revolution Curve File:
Select a .apts file to use as a profile curve for Surface of Revolution

Load Texture File:
Loads another texture to use instead of checkers

Save Image:
Saves a snapshot of your scene view

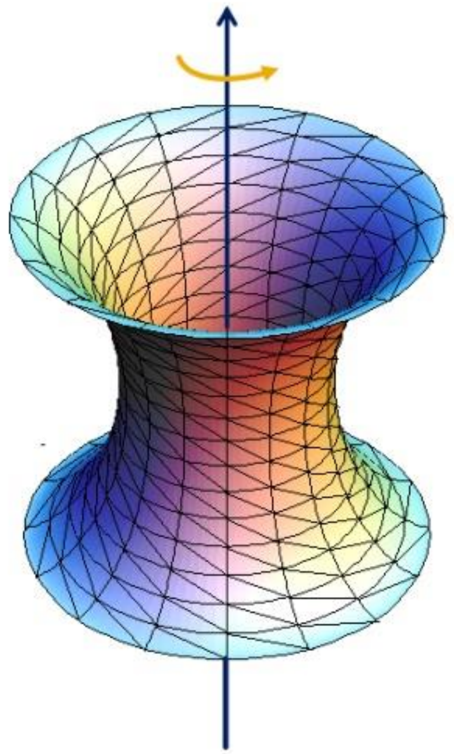


Shading Mode:
Try this out on the sphere, or the surface of revolution

Quality:
Determines the number of subdivisions and polygons to use

Show Light/Camera Markers:
Draws the XYZ Axes in the view and markers for the lights

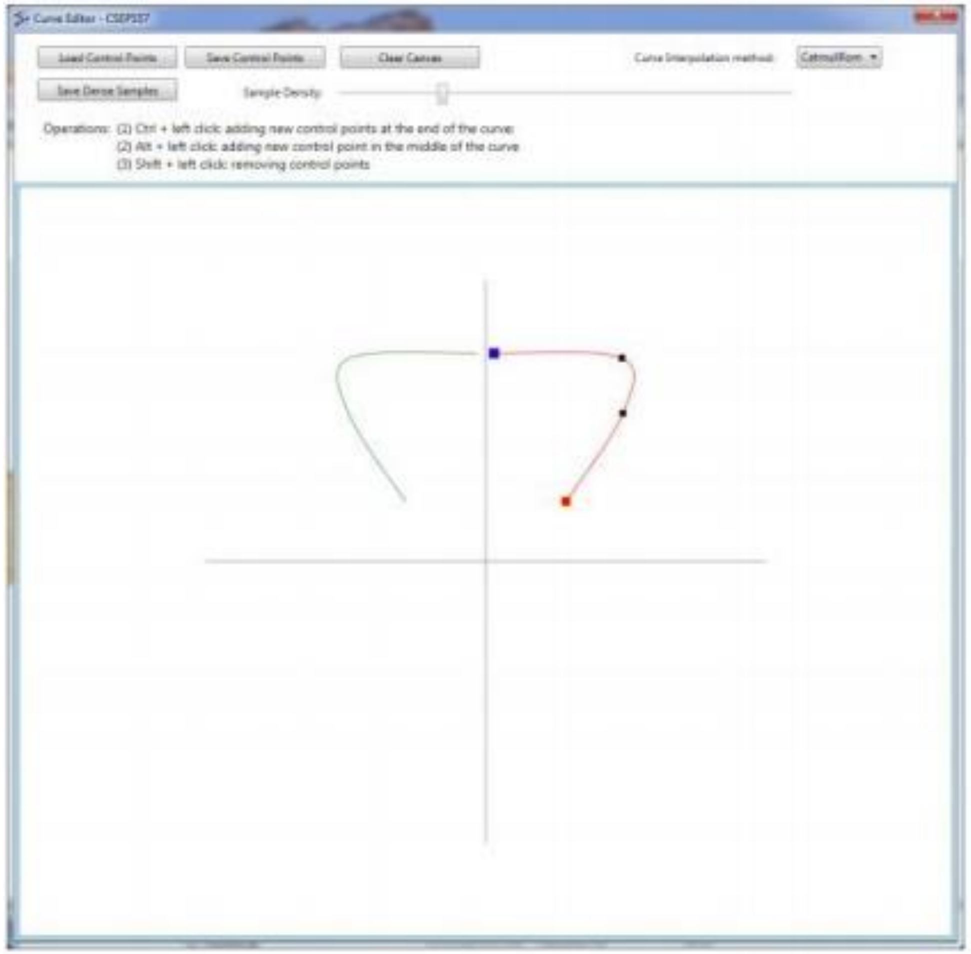
Surface of Revolution



- Write OpenGL code to draw a surface by rotating a profile curve
- You need to calculate the following for each vertex:
  - Texture Coordinates (UV)
  - Normal
  - Position
- Put your code in `void drawRevolution(std::vector<Point2d> *pts, int divisions, double scale)` in modelerdraw.cpp
  - *Divisions* determines the number of slices
  - The skeleton UI calls `void drawRevolution(double scale)`. This implementation is a naïve and incorrect one, but illustrates how curve files can be changed into geometry.
  - You should replace the code that draws the revolution incorrectly with a call to your method.

Curve Editor

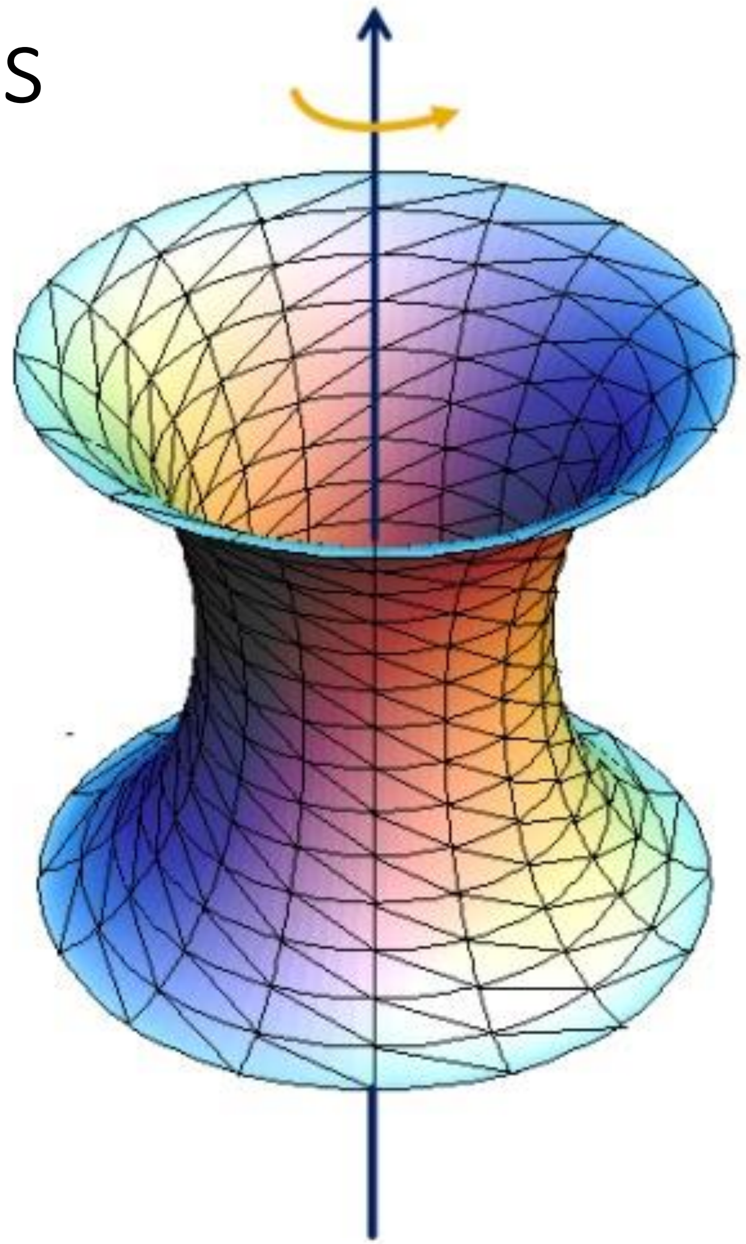
- If it helps to have a simpler profile curve while testing, you can draw your own profile curve.
- The **Curve Editor** tool is linked on the project page.
- Ctrl+Left click to add points on one side
- Save the dense point samples into a .apts file.
- **Load Revolution Curve File** in Modeler



Operations: (1) Ctrl + left click: adding new control points at the end of the curve
(2) Alt + left click: adding new control point in the middle of the curve
(3) Shift + left click: removing control points

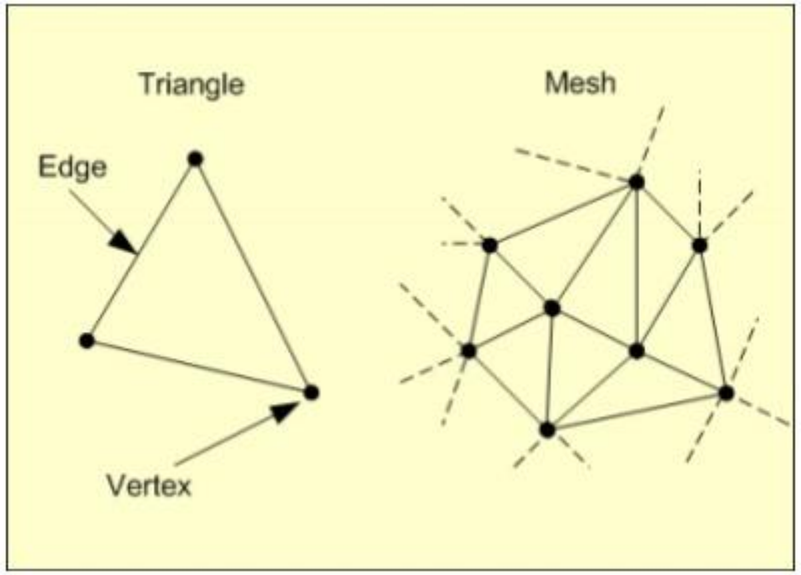
Slicing it into Triangle Bands

- Divide the surface into “bands”
- Compute vertex positions and normal
  - Using sin(), cos(), in C++ code
  - See the “Surfaces of Revolution” lecture slides for how
- Connect the dots with OpenGL triangles



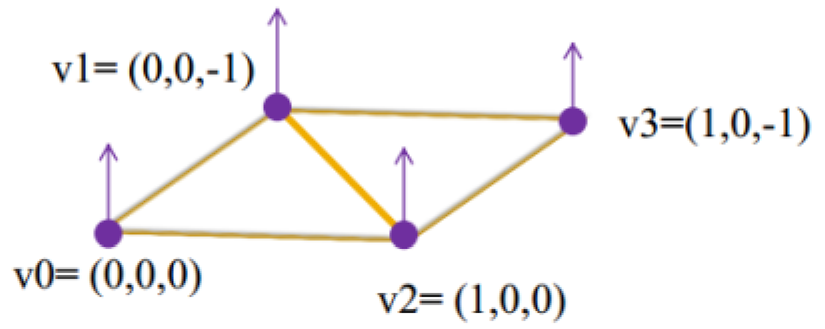
Drawing the Triangles

- Build a triangle mesh and send it to OpenGL
- Construct an array for every piece of vertex information:
  - Vertex position array
  - Vertex normal array
  - Vertex UV array
  - Elements array (the faces of the triangles)
- Use **ONE** glDrawElements call with GL_TRIANGLES (required!)
  - You may use glBegin/glEnd for testing shapes, but do not use them in the final submitted code!
  - You may not use GL_QUAD_STRIP or GL_TRIANGLE_STRIP either.



Example (copy this code!)

This is an overly simplified example of drawing a plane using glDrawElements. The plane consists of two connecting triangles and the normal vectors of all vertices are pointing up.



Notice the data supplied into the arrays are always in the same order.
If the vertices positions are supplied as {V1, V2, V3, V4}, the normal must also be {N1, N2, N3, N4}, and the texture coordinates {T1, T2, T3, T4}

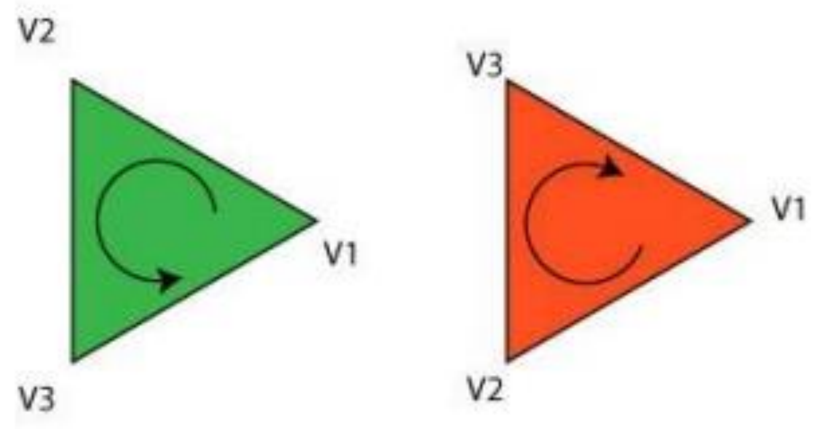
```
// preparing the data for the vertices' positions
GLfloat vertices[12] = { 0,0,0, 0,0,-1, 1,0,0, 1,0,-1 };
// normal directions
GLfloat normals[12] = {0,1,0, 0,1,0, 0,1,0, 0,1,0};
// texture coordinates
GLfloat texture_uv[8] = {0,0, 0,1, 1,0, 1,1};
// vertex indices in order to form triangles
// (order of the vertices follows the right hand rule)
const int indices_length = 6;
GLuint indices[indices_length] = { 1,0,2, 1,2,3 };
```

```
glEnableClientState(GL_VERTEX_ARRAY);
glEnableClientState(GL_NORMAL_ARRAY);
glEnableClientState(GL_TEXTURE_COORD_ARRAY);
glVertexPointer(3, GL_FLOAT, 0, vertices);
glNormalPointer(GL_FLOAT,0,normals);
glTexCoordPointer(2,GL_FLOAT,0,texture_uv);
glDrawElements(GL_TRIANGLES, indices_length
,GL_UNSIGNED_INT, indices);
glDisableClientState(GL_TEXTURE_COORD_ARRAY);
glDisableClientState(GL_NORMAL_ARRAY);
glDisableClientState(GL_VERTEX_ARRAY);
```

Triangle 1 is defined as V1,V0,V2.
Triangle 2 is defined as V1,V2,V3.

Building the Faces

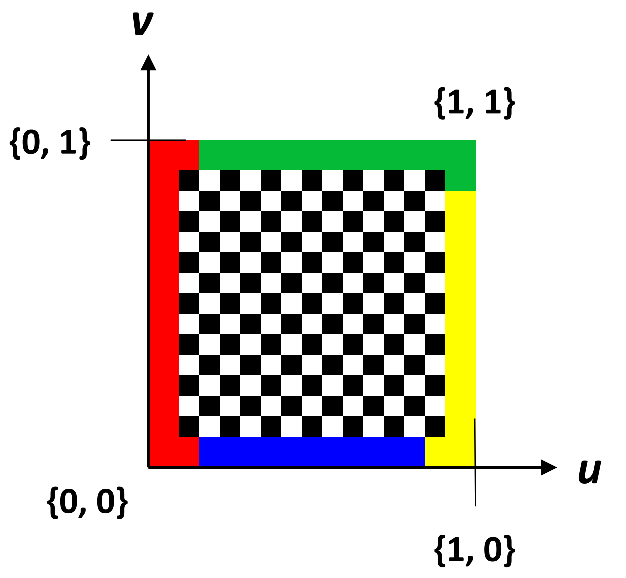
- Order Matters!!
- Depending on the order the faces are constructed, OpenGL will decide which face is the "front" and which is the "back".
- Backfaces are not drawn by default (they are "culled").



The triangle on the left has a CCW winding order so it will be visible on the screen. The triangle on the right has a CW winding order so you will not see it render on the screen.

Texture Mapping

- To compute the UV Texture Coordinates, the basic idea is to remap the arclength (curve distance) and longitude to the range 0-1.
  - i.e. longitude for a vertex on the surface can be from 0-360 degrees. The **u** coordinate can be from 0-1.
  - See the lecture slides on "Texture Mapping" for a more detailed explanation
- Each vertex for your surface of revolution must have:
  - Vertex Position
  - Vertex Normal
  - Texture Coordinate Pair
    - $u,v \in [0,1]$



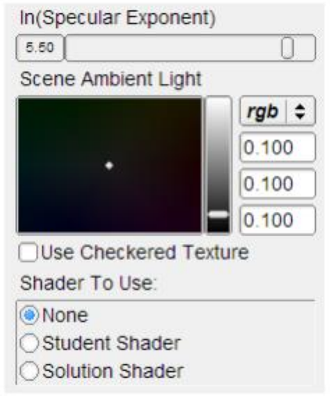
Hierarchical Modeling

- You must make a character with:
  - 2 levels of branching (see project page)
  - Something drawn at each level
  - You will be using this model for your animator animation!
  - Meaningful controls
    - The more controls you add the better. It will make it easier to animate
- You will need to create your own model class

Creating your own model

- Create a new class that inherits from “Model”
  - See sample.cpp and sample.h for an example of this.
- Override the draw method to draw your model
  - You can use drawBox, drawCylinder in Modelerdraw.cpp as references
- You will need to add properties to control it

- Kinds of properties (in properties.h):
  - BooleanProperty = checkbox
  - RangeProperty = slider
  - RGBProperty = color
  - ChoiceProperty = radio buttons
- Need to add it to:
  1. Class definition
  2. Constructor
  3. Property list
- See sample.cpp for example



ln(Specular Exponent) 5.50

Scene Ambient Light rgb 0.100 0.100 0.100

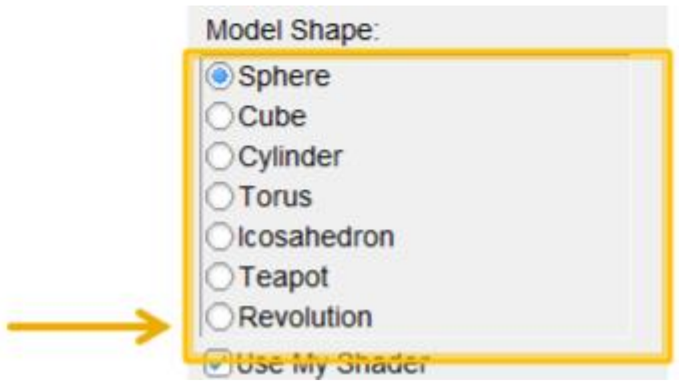
☐ Use Checkered Texture

Shader To Use:

[✓ None]
Student Shader
Solution Shader

Creating your own model

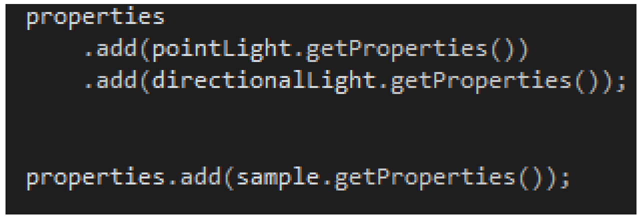
- You will need to then add it as a member of scene.cpp
  - Scene has a method draw() that draws the floor, and a shape depending on the "Model Shape:" property of the Scene.
  - Add your own radio button to the end of the list and a case in this switch to call your model's draw method
- Make sure to add your model's properties to the scene's properties by doing `properties.add(mymodel.getProperties())`
- Make sure to also add any textures and shaders to Scene::Load() to load them whenever the Load Textures and Shaders button is clicked
  - If they are specific to your model, you can add shaders and textures as members of your model class, override the load method of your model, and have scene call your model's load.



Model Shape:

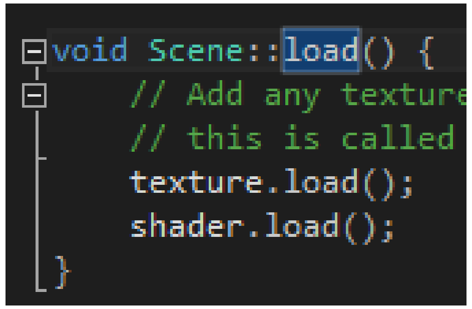
- [✓ Sphere]
- Cube
- Cylinder
- Torus
- Icosahedron
- Teapot
- Revolution

Use My Shader



```
properties
    .add(pointLight.getProperties())
    .add(directionalLight.getProperties());


properties.add(sample.getProperties());
```



```
void Scene::load() {
    // Add any texture
    // this is called
    texture.load();
    shader.load();
}
```

OpenGL is a state machine

- glEnable()/glDisable() changes state
- Once you change something, it stays that way until you change it to something new
- OpenGL’s state includes:
  - Current color
  - Transformation matrices
  - Drawing modes
  - Light sources

OpenGL’s transformation matrix

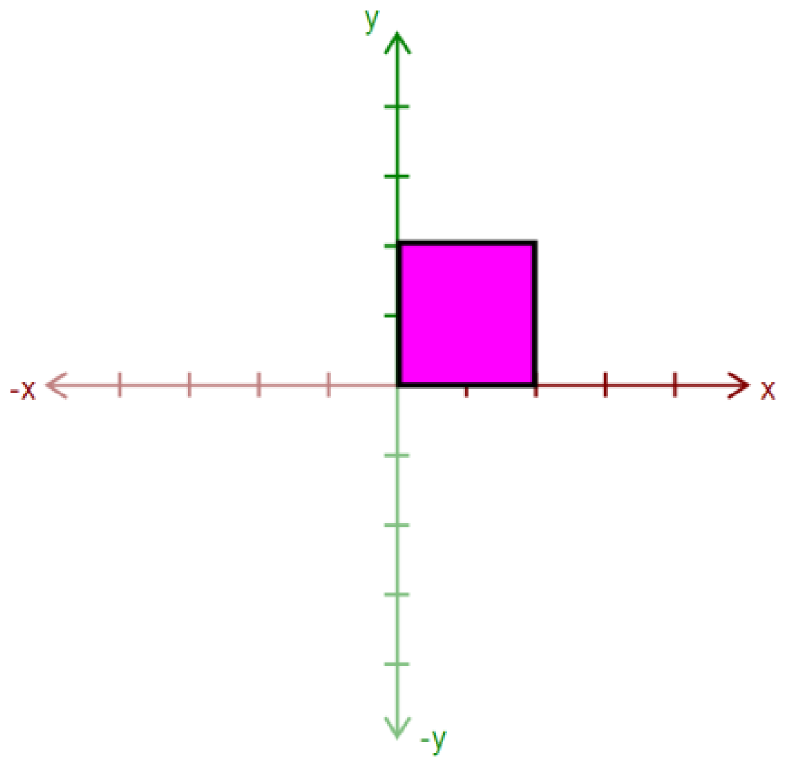
- Just two of them: projection and modelview. We’ll modify modelview.
- Matrix applied to all vertices and normals
- These functions multiply transformations: glRotated(), glTranslated(), glScaled() Applies transformations in REVERSE order from the order in which they are called.
- Transformations are cumulative. Since they’re all “squashed” into one matrix, you can’t “undo” a transformation.

Transformations: Going “back”

- How do we get back to an earlier transformation matrix? We can “remember” it
- OpenGL maintains a stack of matrices.
- To store the current matrix, call glPushMatrix().
- To restore the last matrix you stored, call glPopMatrix().

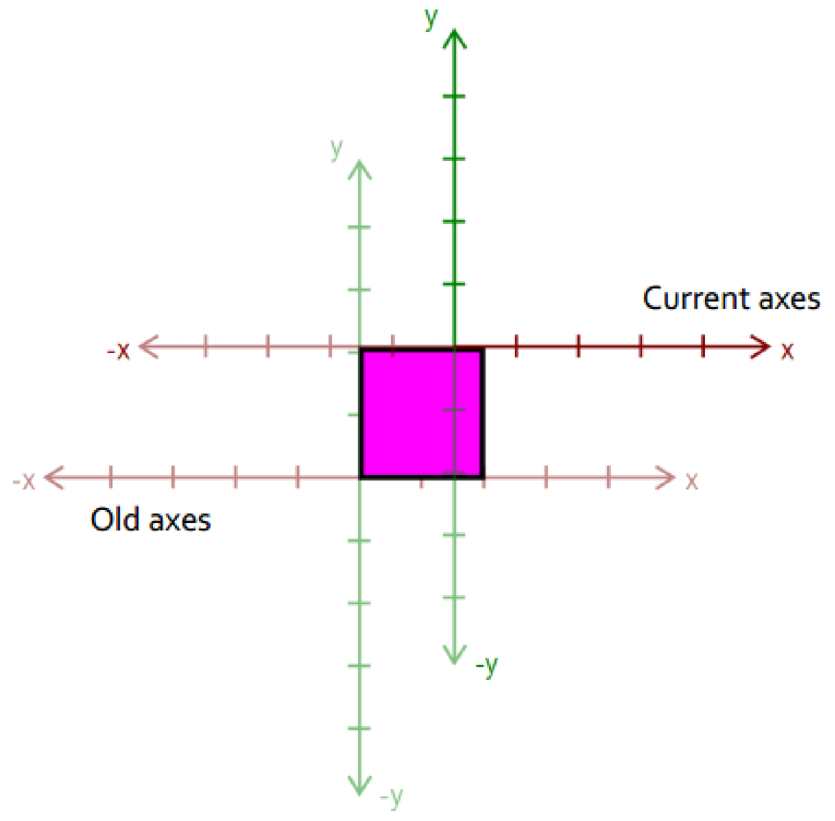
Hierarchical Modeling in OpenGL

- Draw the body
- Use glPushMatrix() to remember the current matrix.
- Imagine that a matrix corresponds to a set of coordinate axes:
  - By changing your matrix, you can move, rotate, and scale the axes OpenGL uses.



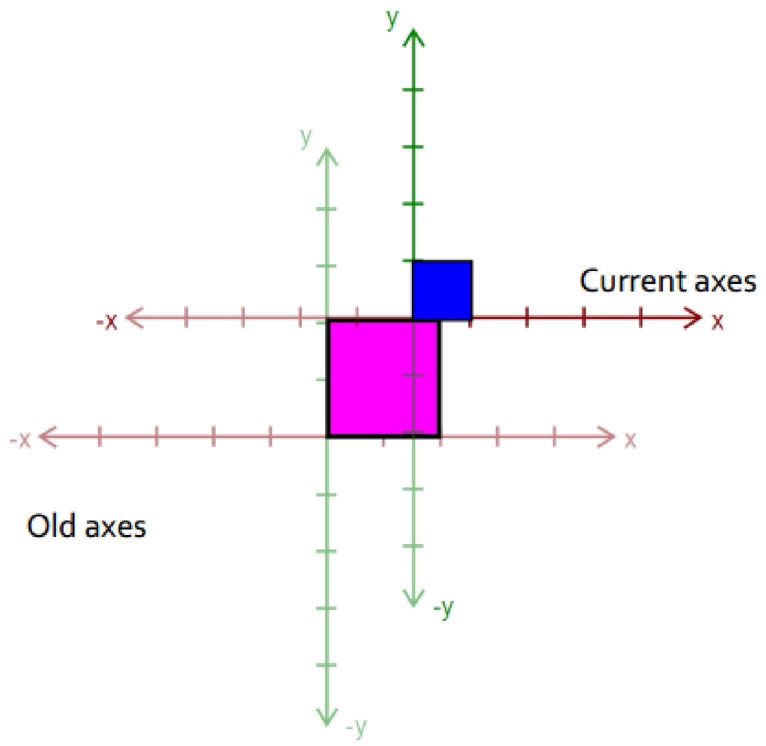
Hierarchical Modeling in OpenGL

- Apply a transform:
  - glRotated()
  - glTranslated()
  - glScaled()
- Here, we apply glTranslated(1.5,2,0)
  - All points translated 1.5 units left and 2 units up
  - It's as if we moved our coordinate axes!



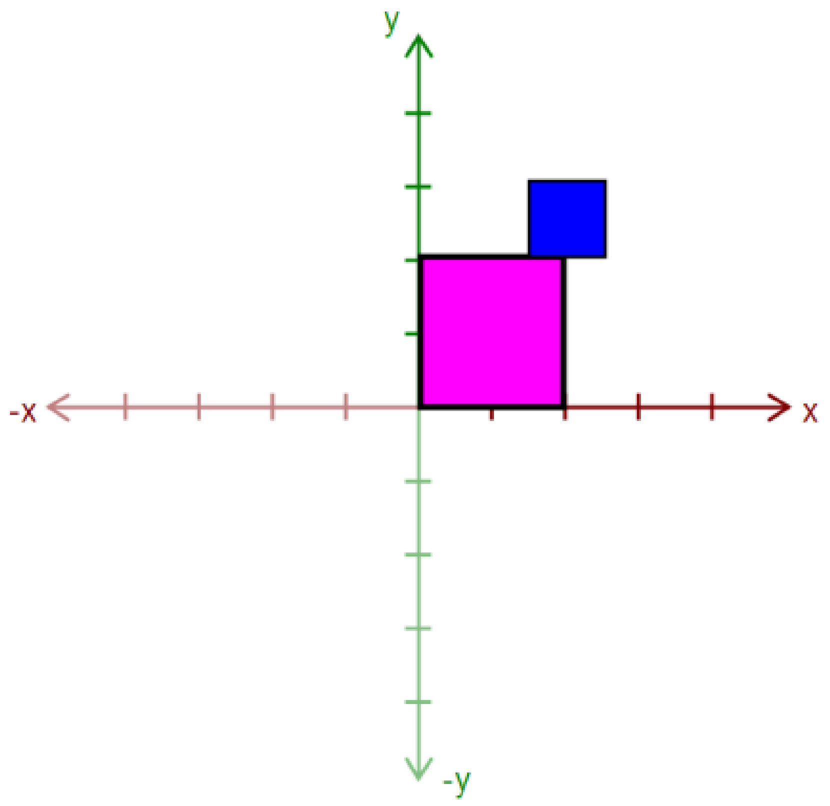
Hierarchical Modeling in OpenGL

- Draw an ear.
  - This ear thinks it was drawn at the origin.
- Transformations let us transform objects without changing their geometry!
  - We didn't have to edit that ear's drawing commands to transform it



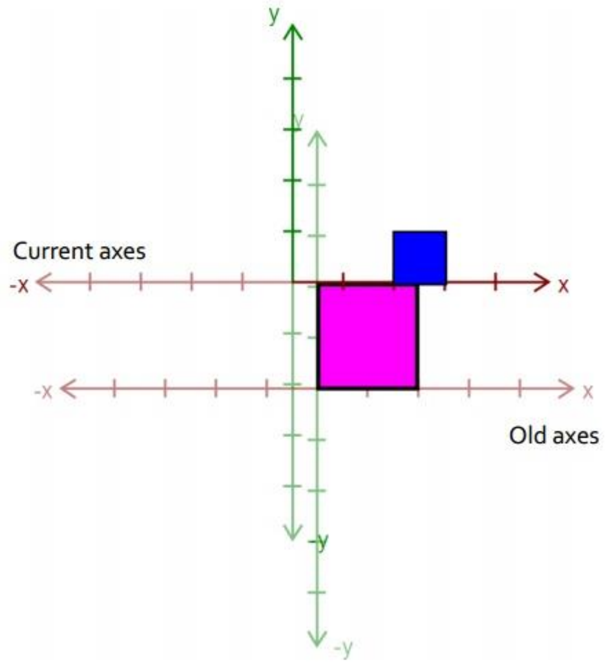
Hierarchical Modeling in OpenGL

- Call glPopMatrix() to return to the body's coordinate axes.
- To draw the other ear, call glPushMatrix() again…

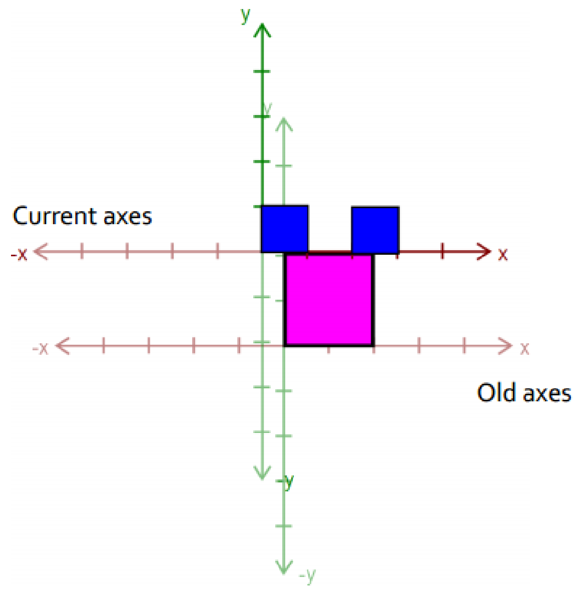


Hierarchical Modeling in OpenGL

- Apply another transform…
  - Where will the ear be drawn now?

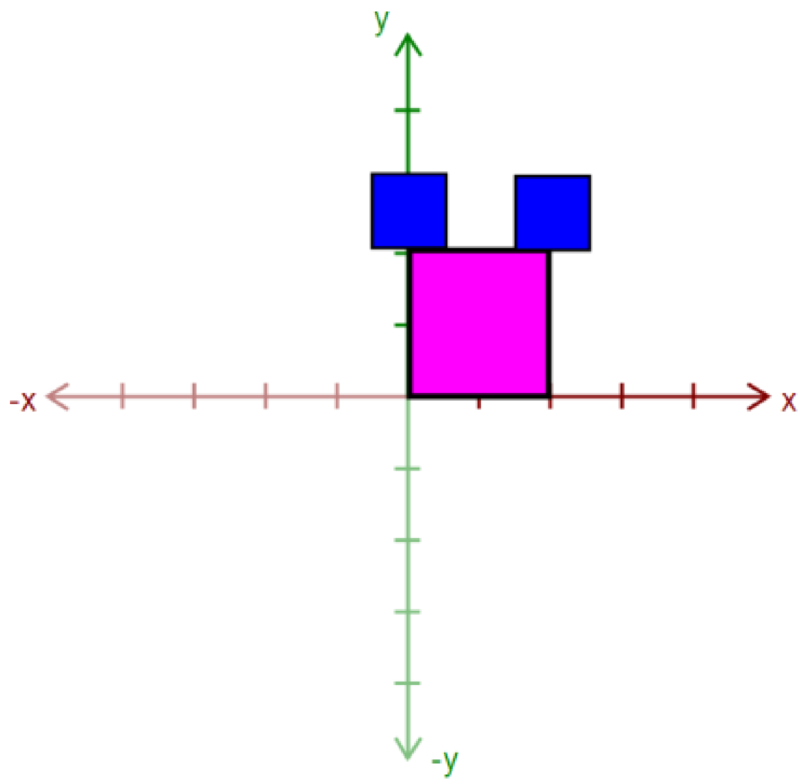


- Draw the other ear



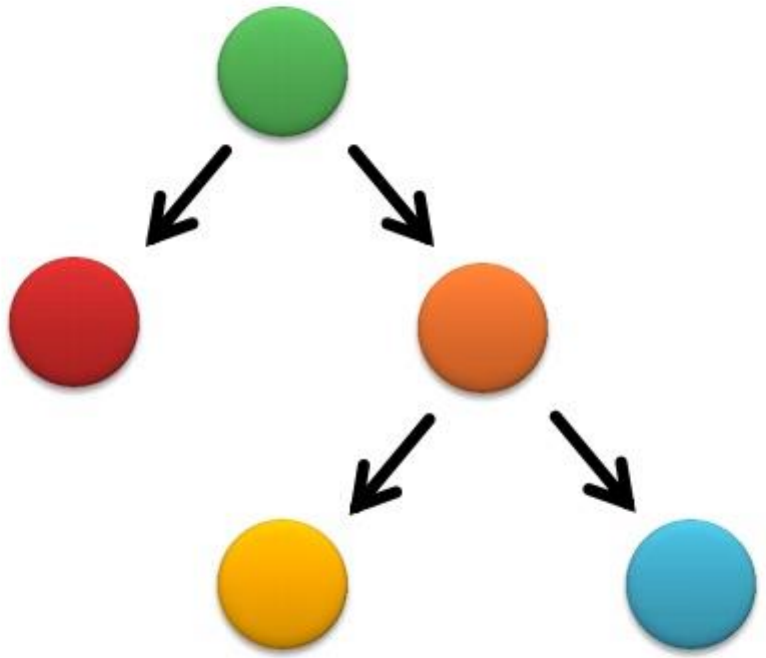
Hierarchical Modeling in OpenGL

- Then, call glPopMatrix() to return to the body's "axes"
  - Technically, you don't need to if that second ear is the last thing you draw.
  - But what if you wanted to add something else to the body?



A pop for every push

- Make sure there's a glPopMatrix() for every glPushMatrix()!
- You can divide your draw() function into a series of nested methods, each with a push at the beginning and a pop at the end.
- Your model must have two levels of branching like in this diagram.
  - Circles are objects
  - Arrows are transformations
- Call glPushMatrix() after drawing green, so you can draw orange after drawing red
  - Do the same for orange
- You must draw something at each level.



Multiple-Joint Slider

- Needs to control multiple aspects of your model.
  - Example: Rotate multiple joints at once
- Don’t get too complicated!
  - Wait for Animator in four weeks!

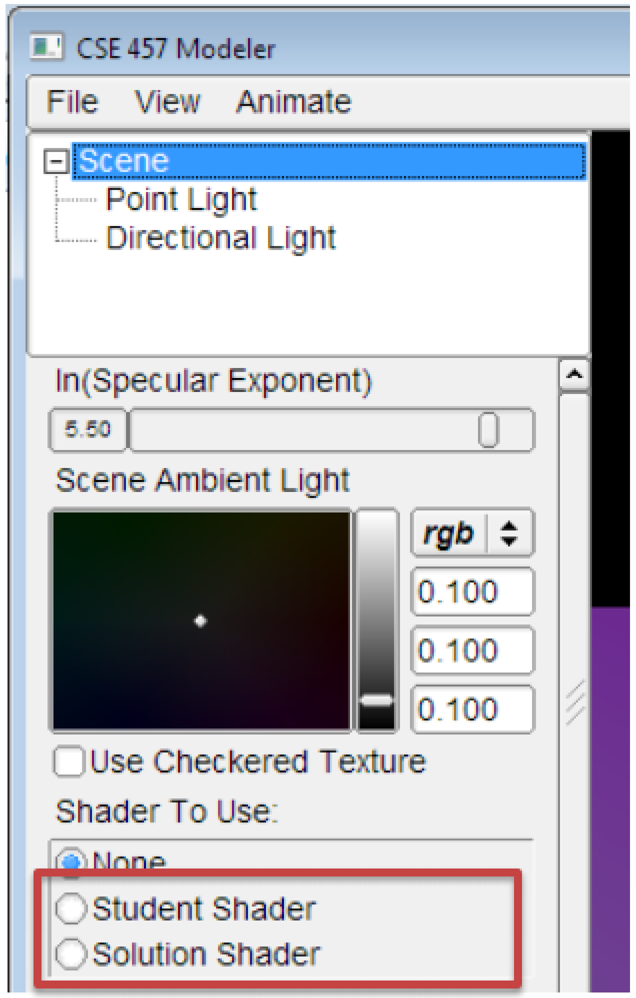
Blinn-Phong Shader

- We provide a directional light shader in OpenGL Shading Language (GLSL). You must extend it to support point lights.
- Files to Edit:
  - shader.frag – your fragment shader
  - shader.vert – your vertex shader

Compare with the Sample Solution

- Modeler_solution.exe loads shader.frag and shader.vert as the “student shader”
- In order to test your Blinn-Phong Point light shader, run the solution from the same folder as your shader.frag, and shader.vert
  - Then under “Shader To Use:” you can switch between your student shader and the solution shader to check the differences.
  - You can also use the “Shader Difference” shader, which highlights any differences between the two. You should end up seeing all black.
    - (There may be some random color pixels scattered around, those are due to floating point errors)

Choose shader here



ln(Specular Exponent) 5.50

Scene Ambient Light 0.100 0.100 0.100

Use Checkered Texture

Shader To Use:
(●) None
( ) Student Shader
( ) Solution Shader

GLSL Variables

- gl_LightSource[i].position.xyz – the position of light source I
- gl_FrontLightProduct[i] – object that stores the product of a light's properties with the current surface's material properties:
  - Example: gl_FrontLightProduct[i].diffuse == gl_FrontMaterial.diffuse * gl_LightSource[i].diffuse

Custom Shader

- Anything you want! (ask us first)
- You are required to do 3 whistles worth, but after that you can earn extra credit.
- Shader_textured.frag and shader_textured.vert are the provided shaders, but they include using a texture to modulate the diffuse color. You may use these as reference to help on some of the options that require texture mapping.
- Shader Resources:
  - http://www.lighthouse3d.com/tutorials/
  - Unity manual on normal mapping
  - Shadertoy has fragment shaders that run on a flat plane only (no vertices other than the 4 for the plane)

Tips

- Start simple when you draw. Draw a few triangles first to make sure it shows up. Then draw a band of triangles.
- When doing glDrawElements, know that each drawcall you do is a hit on performance. So usually we try to have as few drawcalls as possible. If you have more than one drawcall for your surface of revolution, we will deduct points.
- You will need to add your model into the animator project 4, so try not to make changes to too many other files. Otherwise you might need to make those changes again to project 4.
- Make sure to check out the GLSL Shader Tutorials from the Modeler page. Core GLSL is more architecture (has an explanation of the pipeline and shading stages), and GLSL 1.2 is what we're using (has toon shader tutorial etc).

Tips

- If you have additional shaders, make sure to call shader.Load() from the Scene's Load() method. The "Reload Textures and Shaders" button will call the Scene's Load() method, which calls the .load() of texture and shader.
- Your modeler *is* the artifact. This means by the due date for the binary, you need to have your hierachical model done. Special instructions are available for submitting your modeler as an artifact by the artifact due date.
- Make sure to check your Pointlight shader using the **solution's "**Shader Difference". Put your "shader.frag" and "shader.vert" into the same folder as the solution.
- You can check your texture mapping in the skeleton by using the "none" shader with texture enabled. (or you can add the reference textured shader)
- Shaders are hard to debug as there is no “print” statement in GLSL. You must use colors to identify what went wrong, and think about why they might appear that way.