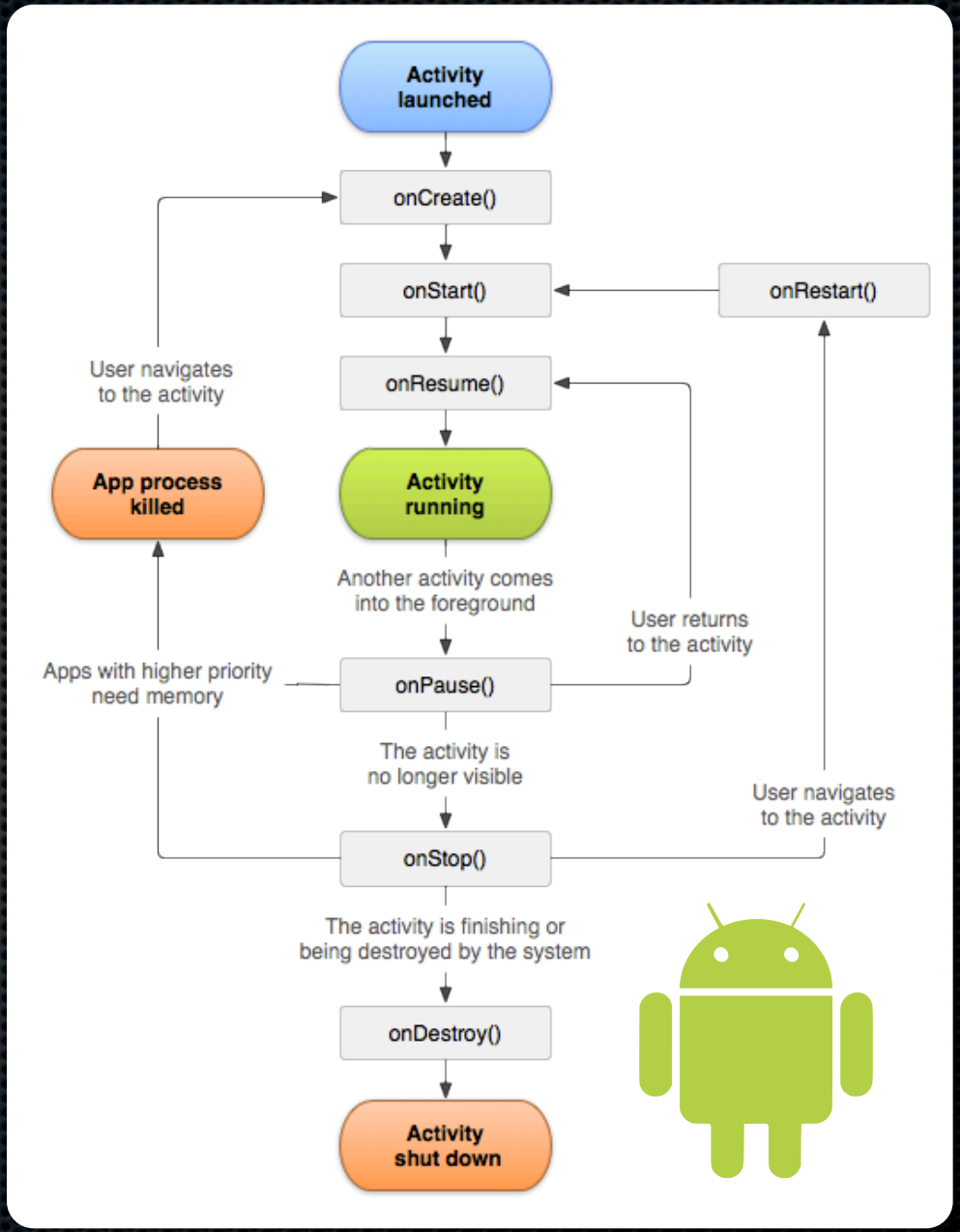
Mobile Application Programing: Android

OpenGL Environment

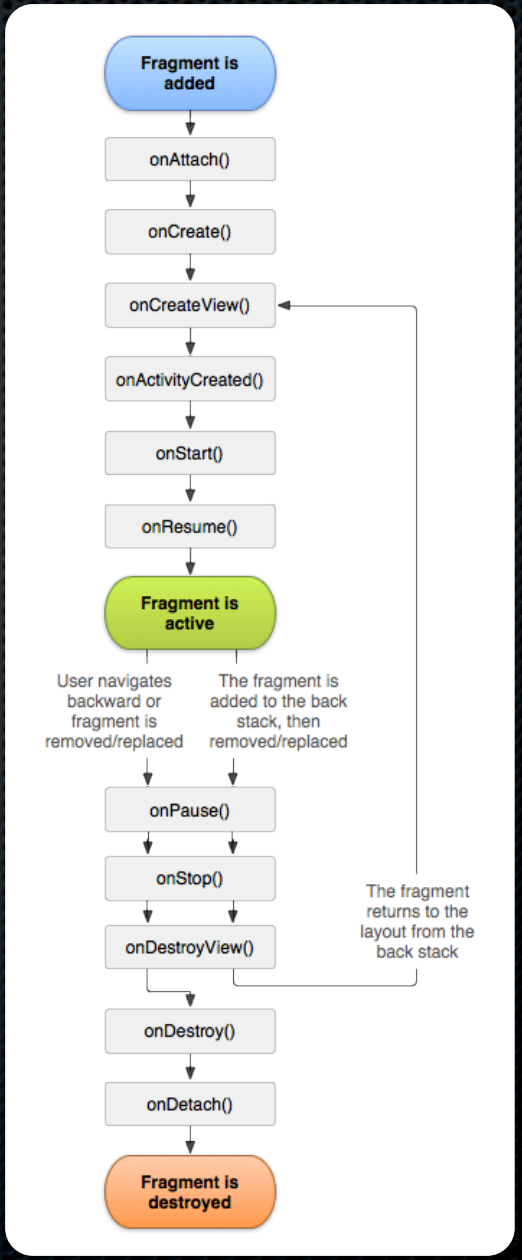
Activities

- Apps are composed of activities
- Activities are self-contained tasks made up of one screen-full of information
- Activities start one another and are destroyed commonly
- Apps can use activities belonging to another app



Fragments

- Acts like a sub-activity
- Attached and removed from an activity using the FragmentManager
- Attachment or removal of many fragments with FragmentTransaction
- Lifecycle tied to parent activity
- Adds onAttach / onDetach and onCreateView / onDestroyView

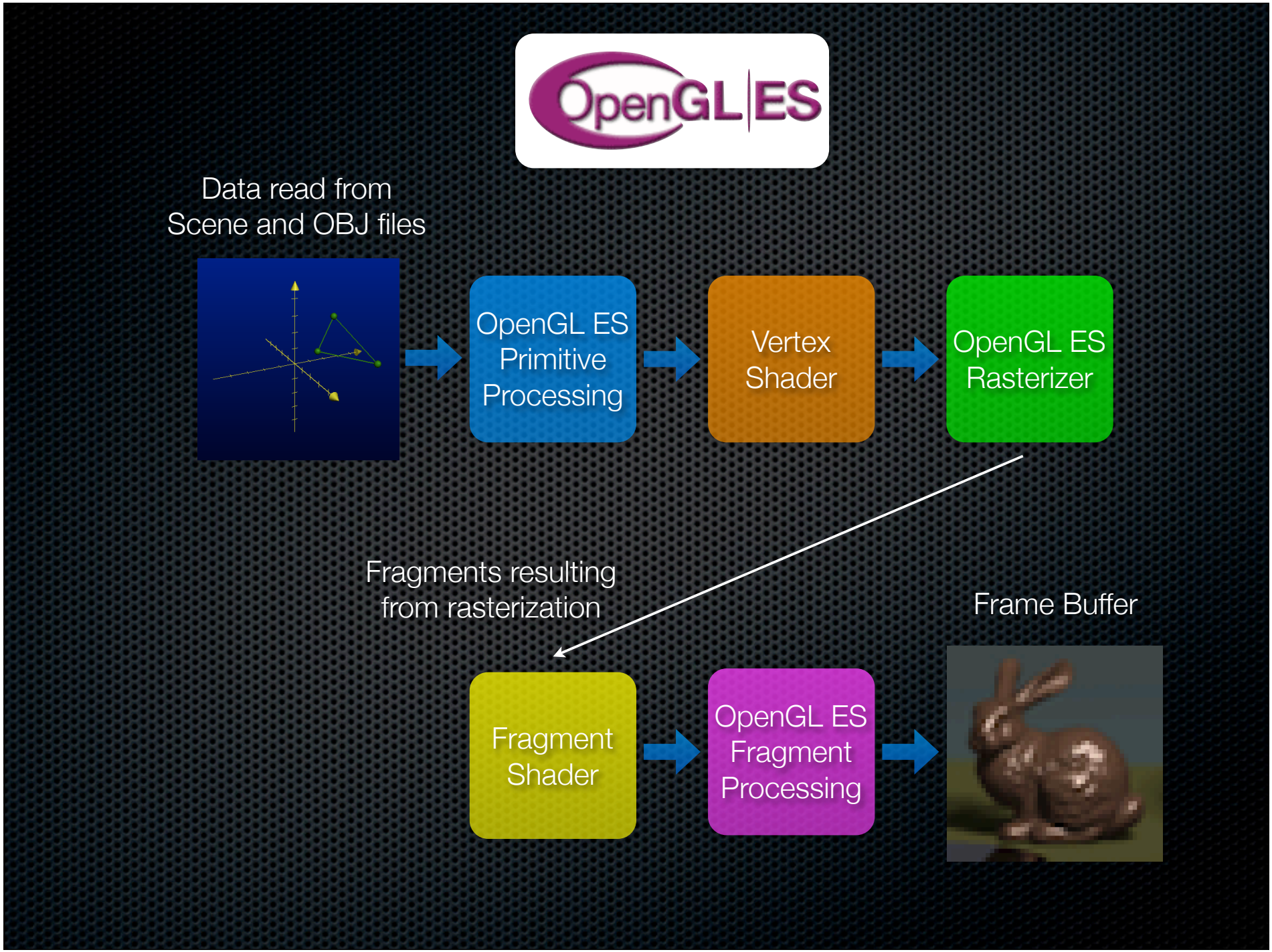


OpenGL ES

- C-Based Performance-Oriented Graphics Library
  - Wrapper libraries provided for Java, C#, etc.
- Produces 2D images from 2D or 3D geometric data
- Mobile version of OpenGL
  - Includes nearly all OpenGL functionality
  - Removes seldom-used or legacy features
  - Used by non-mobile platforms also (eg. Playstation 3)

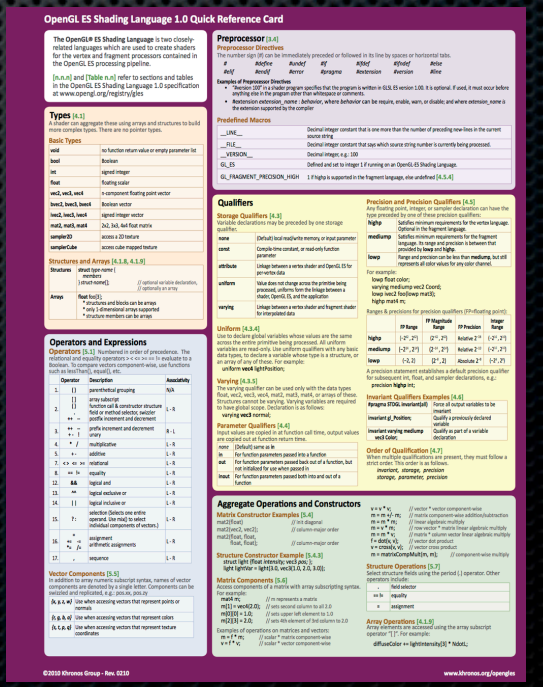
OpenGL Environment

- android.opengl.GLSurfaceView
  - GLSurfaceView.Renderer
    - GLES20 (C Library Wrapper)
      - Vertex Shader
      - Fragment Shader
      - Program
        - Uniform Variables
        - Attribute Arrays


OpenGL ES
Data read from
Scene and OBJ files
OpenGL ES
Primitive
Processing
Vertex
Shader
OpenGL ES
Rasterizer
Fragments resulting
from rasterization
Frame Buffer
Fragment
Shader
OpenGL ES
Fragment
Processing

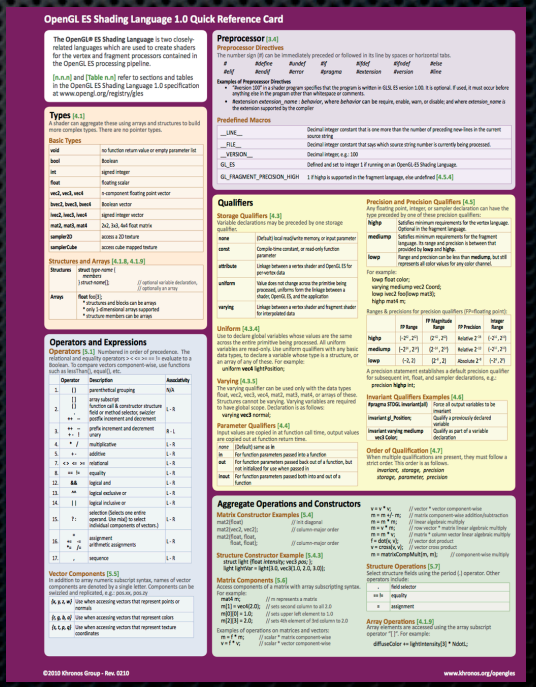
OpenGL Shading Language

- Defines a C-like language that can be compiled into GPU instructions
- Floating-point, Integer, and Boolean data types
- Vectors of these types in 2, 3, 4 sizes
- Matrices of floats in 2x2, 3x3, 4x4
- 1D-Arrays and Structures
- Special Texture types
- Operators on all these types



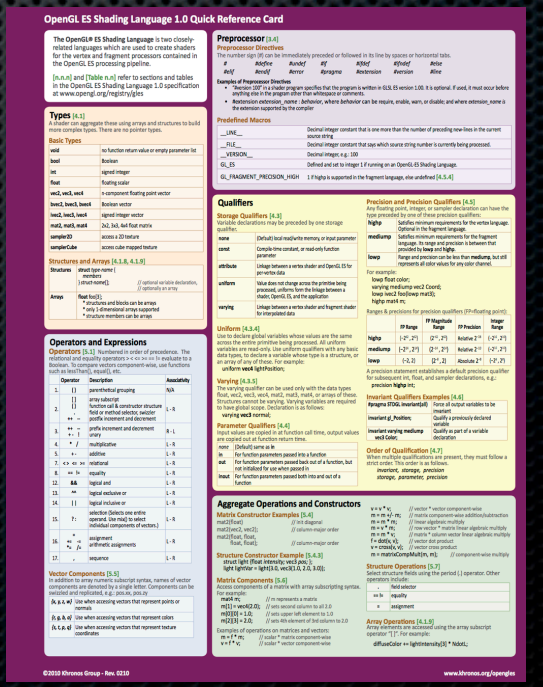
OpenGL Shading Language

- Variable storage qualifiers - uniform, attribute, varying
- Variable precision qualifiers - lowp, mediump, highp
- Control Statements - if, else
- Loops - for, while, do-while
- Jumps - break, continue, return
- Function Definition
- Pre-processor Directives



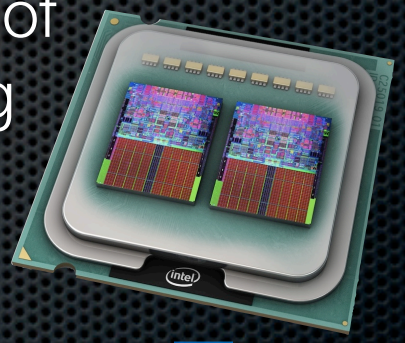
OpenGL Shading Language

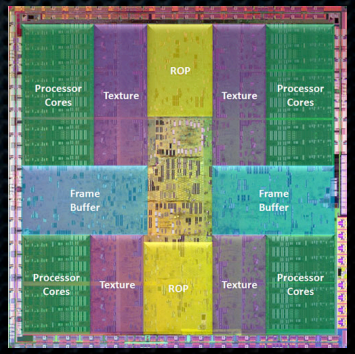
- Built-in functions for basic mathematics, trigonometry, geometry, and texturing (eg. exp, tan, cross, texture2D)
- Built-in variables to represent inputs and outputs
  - Vertex Shader
    - gl_Position (vec4, out)
  - Fragment Shader
    - gl_FragCoord (vec2, in)
    - gl_FragColor (vec4, out)



Host-GPU Data Transfer

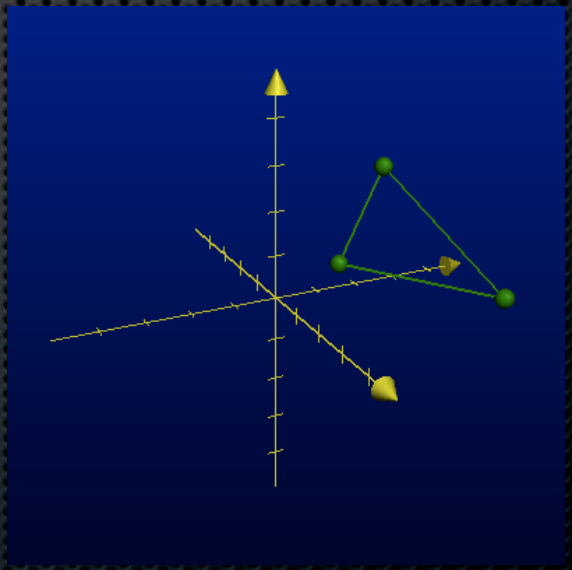
- Global values are sent to the graphics processing hardware by changing the values of uniform variables defined in the shaders using glGetUnifromLocation and glUniform* calls
- Geometry data is sent to the graphics hardware by using glBindAttribLocation, glEnableVertexAttribArray, glVertexAttribPointer
- Textures are sent to the graphics processing hardware by calling glBindTexture and glTexImage2D
- Drawing is initiated by calling glDrawArrays



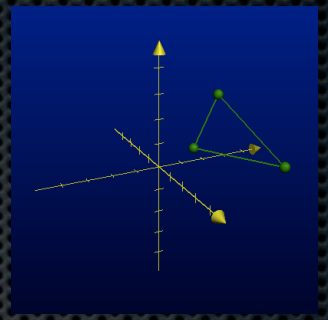


Vertex Shader

- Receives a vertex from OpenGL after minimal processing
- Modifies incoming vertex in some way using uniform variables where needed
- Outputs the vertex
- May also output additional data for the fragment shader to use



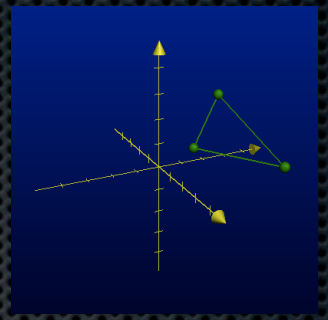
Vertex Shader



```
attribute vec4 position;

void main()
{
    gl_Position = position;
}
```

Vertex Shader

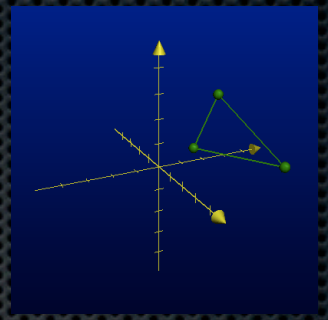


```
attribute vec4 position;

uniform mat4 modelView;

void main()
{
    gl_Position = modelView * position;
}
```

Vertex Shader

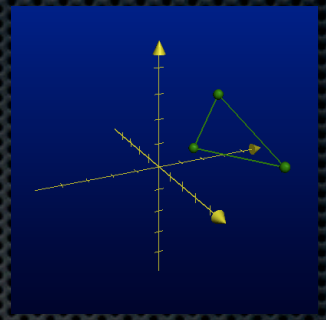


```
attribute vec4 position;

uniform mat4 modelView;
uniform mat4 projection;

void main()
{
    gl_Position = projection * modelView * position;
}
```

Vertex Shader



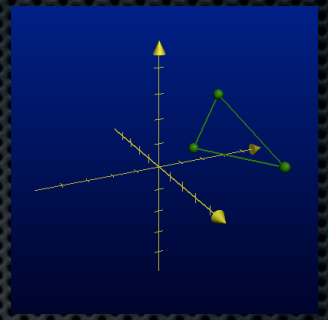
```
attribute vec4 position;
attribute vec2 textureCoordinate;

uniform mat4 modelView;
uniform mat4 projection;

varying lowp vec2 textureCoordinateVarying;

void main()
{
    gl_Position = projection * modelView * position;
    textureCoordinateVarying = textureCoordinate;
}
```

Vertex Shader



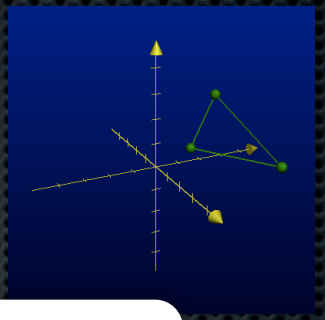
```
attribute vec4 position;
attribute vec3 normal;
attribute vec2 textureCoordinate;

uniform mat4 modelView;
uniform mat4 projection;

varying lowp vec3 normalVarying;
varying lowp vec2 textureCoordinateVarying;

void main()
{
    gl_Position = projection * modelView * position;
    normalVarying = vec3(normalize(modelView * vec4(normal, 0.0)));
    textureCoordinateVarying = textureCoordinate;
}
```

Vertex Shader



```
attribute vec4 position;
attribute vec3 normal;
attribute vec2 textureCoordinate;

uniform mat4 modelView;
uniform mat4 projection;

uniform vec4 lightPosition;
uniform vec4 lightAmbient;
uniform vec4 lightDiffuse;

varying lowp vec3 normalVarying;
varying lowp vec2 textureCoordinateVarying;
varying lowp vec4 diffuseVarying;

void main()
{
    gl_Position = projection * modelView * position;
    normalVarying = vec3(normalize(modelView * vec4(normal, 0.0)));
    textureCoordinateVarying = textureCoordinate;

    vec4 lightVector = normalize(lightPosition - gl_Position);
    float lightIncidence = dot(lightVector, vec4(normalVarying, 1.0));
    diffuseVarying = lightDiffuse * vec4(max(lightIncidence, 0.0));
}
```

Fragment Shader

- Receives a fragment from OpenGL resulting from rasterizing a primitive
- Chooses a color for the fragment based on data given by vertex shader and uniform variables
- Outputs the fragment color

Fragment Shader

```
void main()
{
    gl_FragColor = vec4(1.0, 1.0, 0.0, 1.0);
}
```

Fragment Shader

```
uniform vec4 color;

void main()
{
    gl_FragColor = color;
}
```

Fragment Shader

```
varying vec4 color;

void main()
{
    gl_FragColor = color;
}
```

Fragment Shader

```
uniform sampler2D textureUnit;

varying vec2 textureCoordinate;

void main()
{
    gl_FragColor = texture2D(textureUnit, textureCoordinate);
}
```

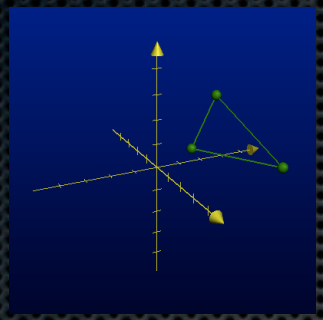
Fragment Shader

```
uniform vec4 color;
uniform vec4 lightPositionEyeCoords;

varying vec4 positionEyeCoords;
varying vec3 normalEyeCoords;

void main()
{
    vec3 incident = vec3(normalize(lightPositionEyeCoords - positionEyeCoords));
    vec3 normal = normalEyeCoords;
    float incidence = max(0.0, dot(incident, normal));
    gl_FragColor = color * incidence;
}
```

Shaders



```
attribute vec4 position;
attribute vec3 normal;
attribute vec2 textureCoordinate;

uniform mat4 modelView;
uniform mat4 projection;

uniform vec4 lightPosition;
uniform vec4 lightAmbient;
uniform vec4 lightDiffuse;

varying lowp vec3 normalVarying;
varying lowp vec2 textureCoordinateVarying;
varying lowp vec4 diffuseVarying;

void main()
{
    gl_Position = projection * modelView * position;
    normalVarying = vec3(normalize(modelView * vec4(normal, 0.0)));
    textureCoordinateVarying = textureCoordinate;

    vec4 lightVector = normalize(lightPosition - gl_Position);
    float lightIncidence = dot(lightVector, vec4(normalVarying, 1.0));
    diffuseVarying = lightDiffuse * vec4(max(lightIncidence, 0.0));
}
```

```
uniform vec4 color;
uniform vec4 lightPositionEyeCoords;

varying vec4 positionEyeCoords;
varying vec3 normalEyeCoords;

void main()
{
    vec3 incident = vec3(normalize(lightPositionEyeCoords - positionEyeCoords));
    vec3 normal = normalEyeCoords;
    float incidence = max(0.0, dot(incident, normal));
    gl_FragColor = color * incidence;
}
```