COMP220: Graphics & Simulation

4: Meshes

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More complex meshes

Winding order

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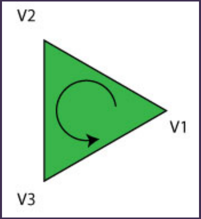

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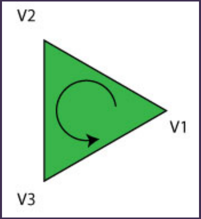

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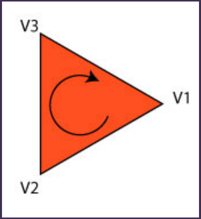

If the vertices go **clockwise**, you are looking at the **back**

Backface culling

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```
glEnable(GL_CULL_FACE);
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- This will cause only the front faces of triangles to be drawn
- Triangles whose front face is not visible will be **culled**
- Culled faces are not passed through the rasteriser or fragment shader
- Saves time, and should make no difference to appearance — as long as all meshes are closed and have correct winding

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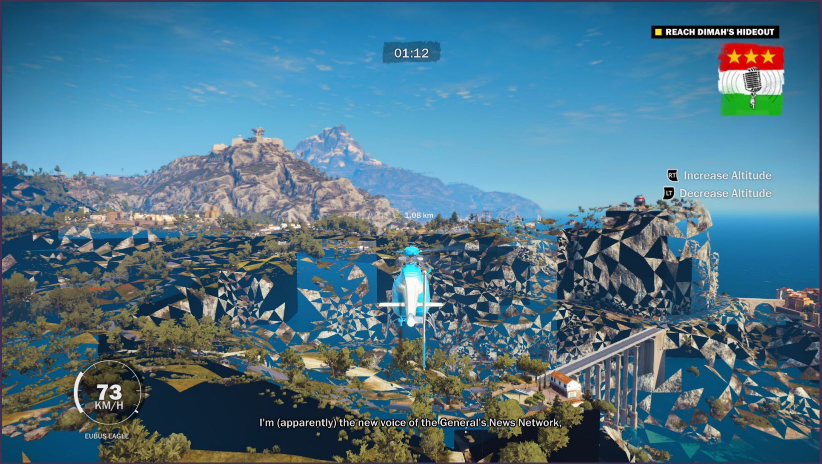
When backface culling goes bad?



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Vertices

Interleaved Vertices

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- This is known as Interleaved Vertices and in **MOST** cases is more efficient

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Vertex Structure 1

```
struct Vertex
{
    float x,y,z;
};

Vertex v[]={{-0.5f,-0.5f,0.0f},
            {0.5f,-0.5f,0.0f},
            {0.0f,0.5f,0.0f}};
```

Vertex Structure 2

```
struct Vertex
{
    float x,y,z;
    float r,g,b,a;
};

Vertex v[]={{-0.5f,-0.5f,0.0f,1.0f,0.0f,0.0f ↩
    ,1.0f},
            {0.5f,-0.5f,0.0f,0.0f,1.0f,0.0f ↩
                ,1.0f},
            {0.0f,0.5f,0.0f,0.0f,0.0f,1.0f,1.0 ↩
                f}};
```

Changes to the Vertex Buffer

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Changes to the Vertex Buffer

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- We have to take into account the size of the Vertex structure and the number of vertices in the buffer

Vertex Buffer Changes - Old version

```
glBufferData(GL_ARRAY_BUFFER, sizeof( ↩
    g_vertex_buffer_data), ↩
    g_vertex_buffer_data, GL_STATIC_DRAW);
```

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Vertex Buffer Changes - new version

```
glBufferData(GL_ARRAY_BUFFER, 3* sizeof(Vertex ↩
    ), v, GL_STATIC_DRAW);
```

Changes to the Vertex Array

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- Since the layout of the vertices have changed in memory, we need to update the Vertex Array Object to reflect this
- Remember that the VAO describes the format of the vertices to the pipeline and enables the binding of vertex data to attributes in the shader

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Vertex Array Object - Old version

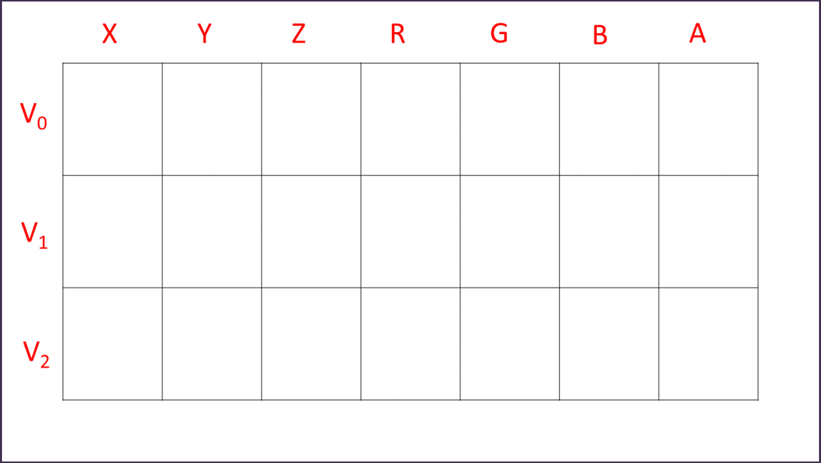
```
    glEnableVertexAttribArray(0);
    glVertexAttribPointer(0,3,GL_FLOAT,GL_FALSE,0,( ↩
        void*)0);
```

Vertex Array Object - New version

```
glEnableVertexAttribArray(0);
glVertexAttribPointer(0,3,GL_FLOAT,GL_FALSE,sizeof ↩
    (Vertex),(void*)0);

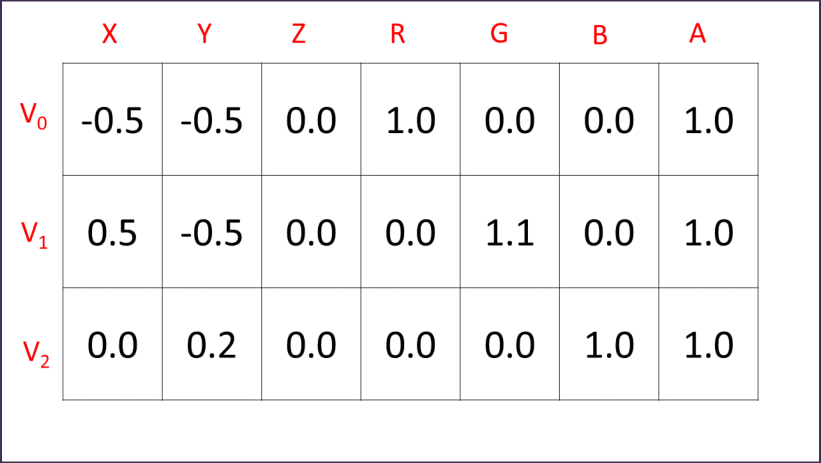
glEnableVertexAttribArray(1);
glVertexAttribPointer(1,4,GL_FLOAT,GL_FALSE,sizeof ↩
    (Vertex),(void*)(3*sizeof(float)));
```

Memory and Vertex Array Object 1



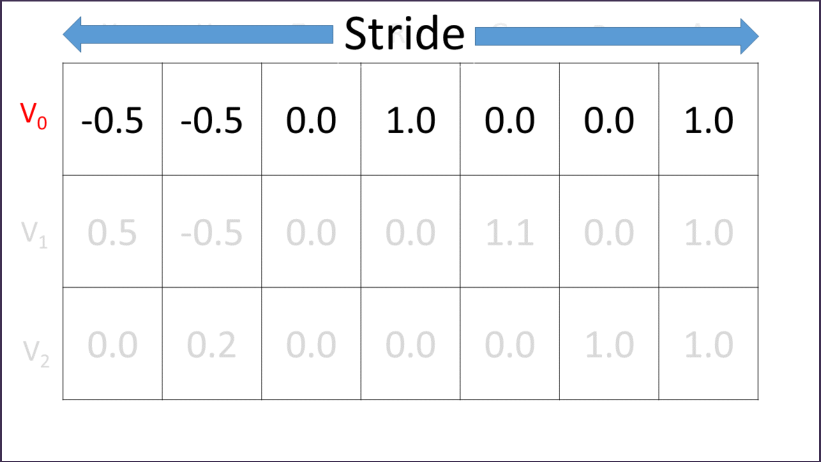
	X	Y	Z	R	G	B	A
V_0							
V_1							
V_2							

Memory and Vertex Array Object 2



	X	Y	Z	R	G	B	A
V_0	-0.5	-0.5	0.0	1.0	0.0	0.0	1.0
V_1	0.5	-0.5	0.0	0.0	1.1	0.0	1.0
V_2	0.0	0.2	0.0	0.0	0.0	1.0	1.0

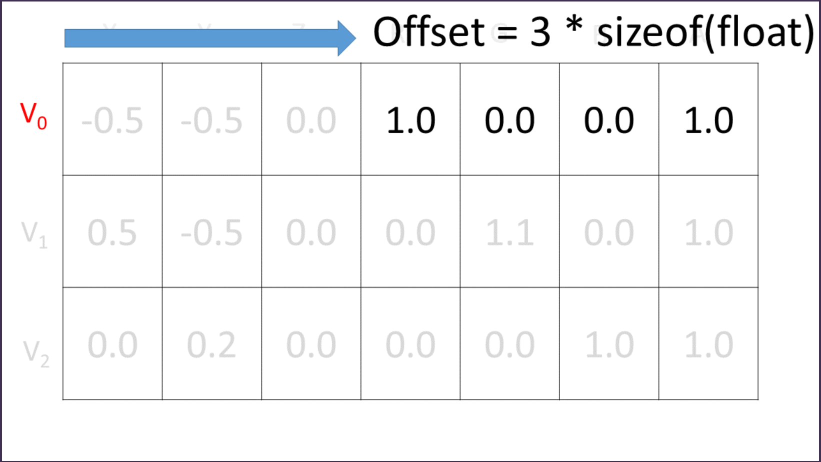
Memory and Vertex Array Object 3 - Stride



Stride

V_0	-0.5	-0.5	0.0	1.0	0.0	0.0	1.0
V_1	0.5	-0.5	0.0	0.0	1.1	0.0	1.0
V_2	0.0	0.2	0.0	0.0	0.0	1.0	1.0

Memory and Vertex Array Object 3 - Offset



Offset = 3 * sizeof(float)

V_0	-0.5	-0.5	0.0	1.0	0.0	0.0	1.0
V_1	0.5	-0.5	0.0	0.0	1.1	0.0	1.0
V_2	0.0	0.2	0.0	0.0	0.0	1.0	1.0

Element Buffer

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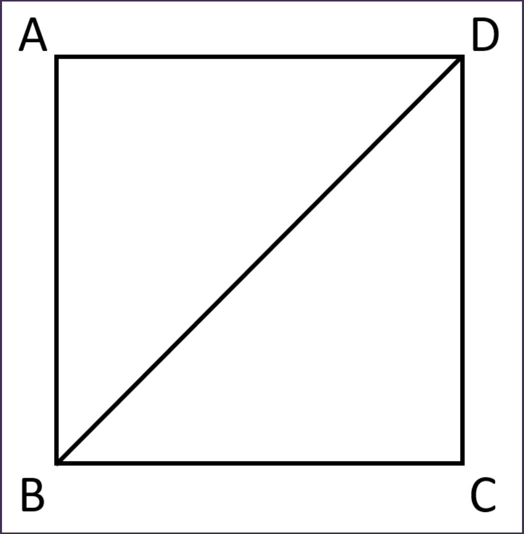
- This is a bit wasteful considering that some of these vertices are duplicates
- We can use an **Element Buffer** to optimise our drawing
- An Element Buffer holds an integer which is an offset into a Vertex Buffer

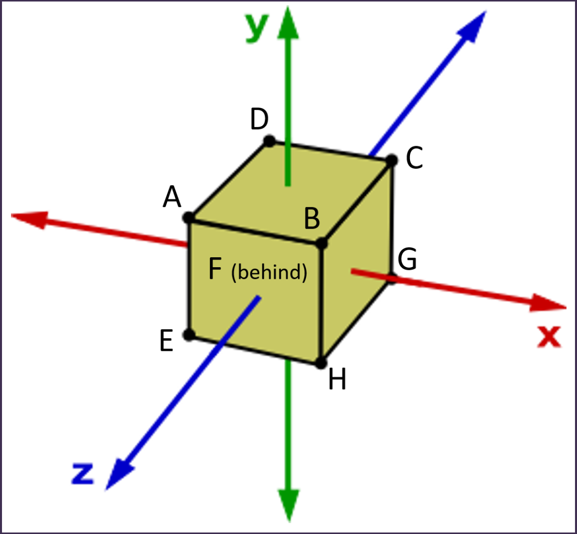
Creating & Using Element Buffer

Live Coding

Exercise 1 - Let’s draw a square!



Exercise 2 - Let's draw a cube!



Exercise 3 - Element Buffer

- Create a cube using an Element Buffer
- Create a function which fills a Vertex Buffer and Element Buffer for drawing a Sphere

Further Reading - Interleaved Vertices

- iOS Development Docs - `https://developer.apple.com/library/content/documentation/3DDrawing/Conceptual/OpenGLES_ProgrammingGuide/TechniquesforWorkingwithVertexData/TechniquesforWorkingwithVertexData.html`
- To interleave or not to interleave - `https://anteru.net/blog/2016/02/14/3119/index.html`
- Vertex Specification Best Practices - `https://www.khronos.org/opengl/wiki/Vertex_Specification_Best_Practices`

Further Reading - Element Buffer

- VBO indexing - `http://www.opengl-tutorial.org/intermediate-tutorials/tutorial-9-vbo-indexing/`
- Element Buffer - `https://goharsha.com/lwjgl-tutorial-series/element-buffer-objects/`