COMP220: Graphics & Simulation

4: Meshes

Module Roadmap

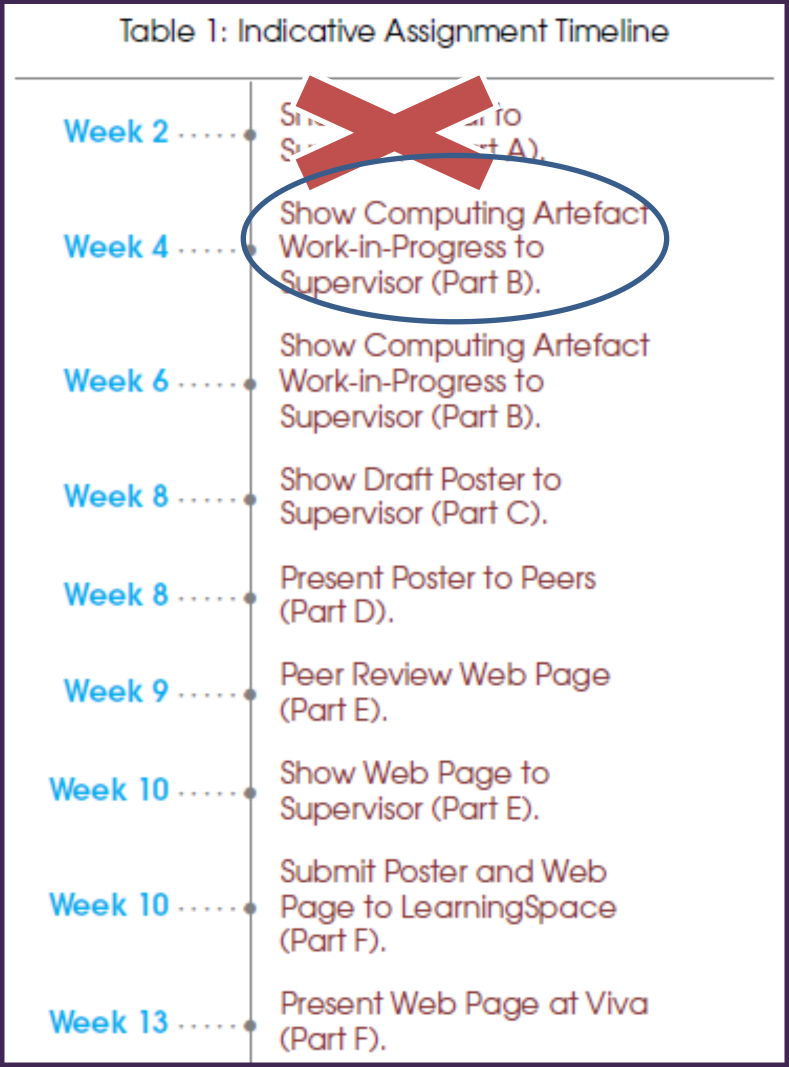

Table 1: Indicative Assignment Timeline

	Week 2	~~Sh[illegible] to S[illegible]t A).~~
Worksheet A	Week 4	Show Computing Artefact Work-in-Progress to Supervisor (Part B).
Worksheet B	Week 6	Show Computing Artefact Work-in-Progress to Supervisor (Part B).
Worksheet C	Week 8	Show Draft Poster to Supervisor (Part C).
	Week 8	Present Poster to Peers (Part D).
	Week 9	Peer Review Web Page (Part E).
Worksheet D	Week 10	Show Web Page to Supervisor (Part E).
	Week 10	Submit Poster and Web Page to LearningSpace (Part F).
	Week 13	Present Web Page at Viva (Part F).

More complex meshes

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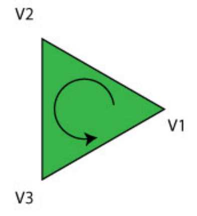

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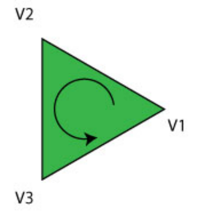

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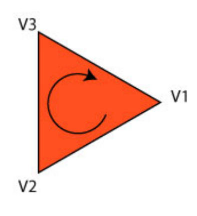

If the vertices go **clockwise**, you are looking at the **back**

Backface culling

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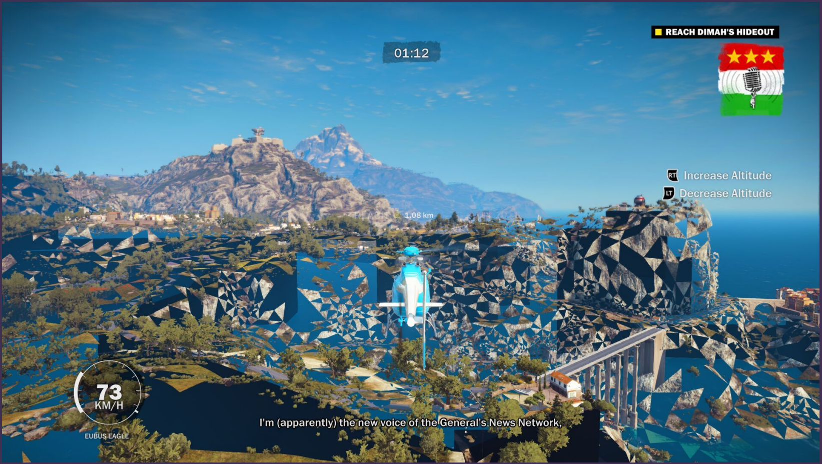
- This will cause only the front faces of triangles to be drawn
- Triangles whose front face is not visible will be **culled**
- Culled faces are not passed through the rasteriser or fragment shader
- Saves time, and should make no difference to appearance — as long as all meshes are closed and have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

When backface culling goes bad?



Vertices

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

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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- 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);
```

Vertex Buffer Changes - new version

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

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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

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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

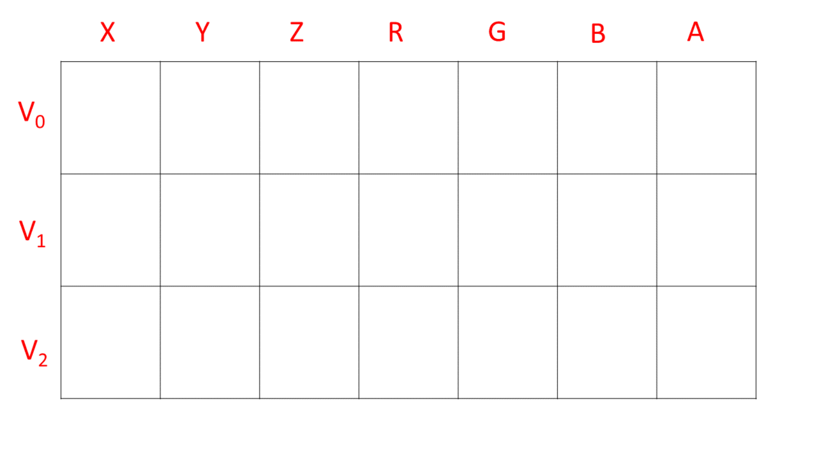
Vertex Array Object - Old version

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

Vertex Array Object - New version

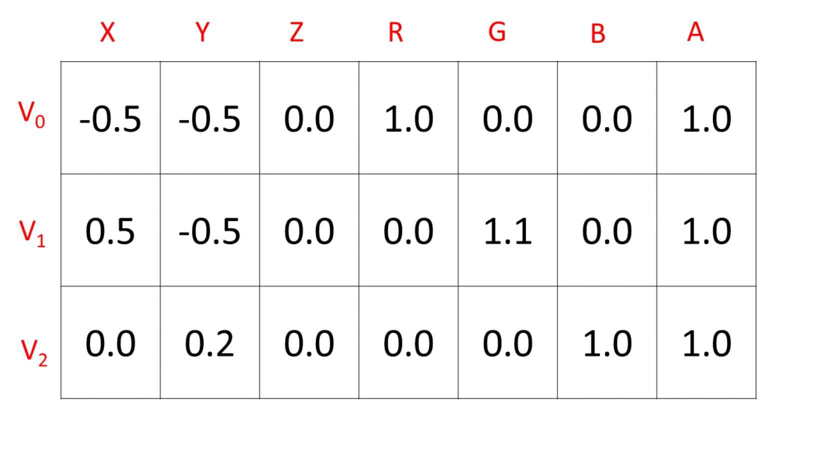
```
    glEnableVertexAttribArray(0);
    glVertexAttribPointer(0,3,GL_FLOAT,GL_FALSE,sizeof ↩
        (Vertex),(void*)0);

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

Memory and Vertex Array Object 1



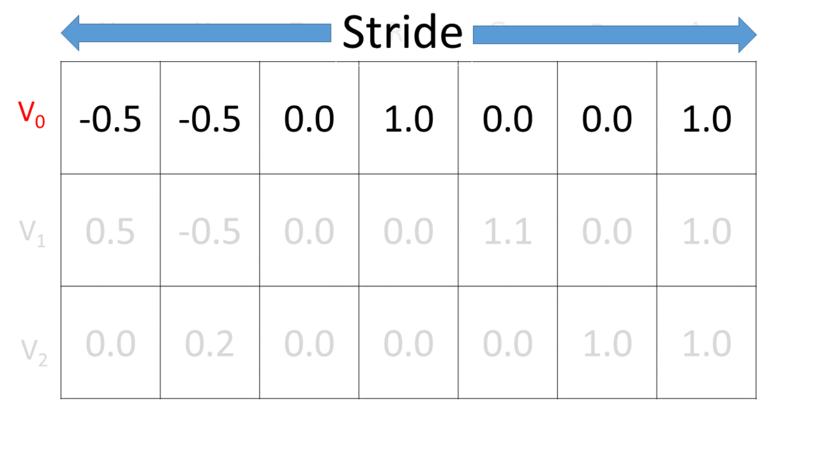
	X	Y	Z	R	G	B	A
V_0							
V_1							
V_2							

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)

	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

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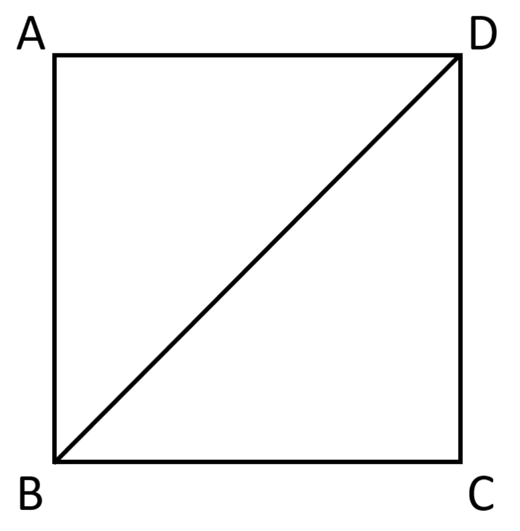
- This is a bit wasteful considering that some of these vertices are duplicates
- We can use an **Element Buffer** to optimise our drawing
- An Element Buffer holds an integer which is an offset into a Vertex Buffer

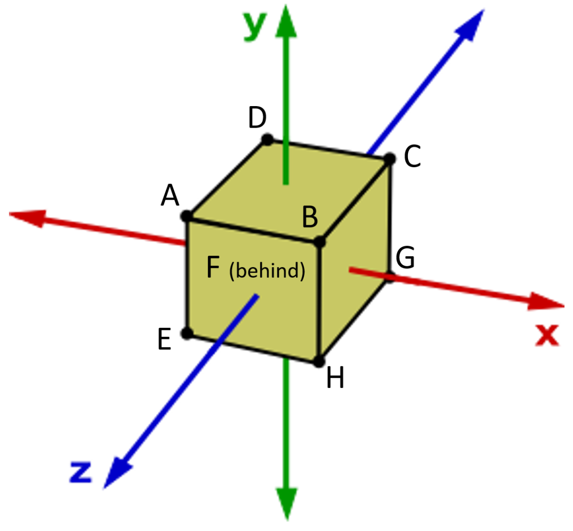
Creating & Using Element Buffer

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/`