COMP220: Graphics & Simulation

4: Meshes

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More complex meshes

Winding order

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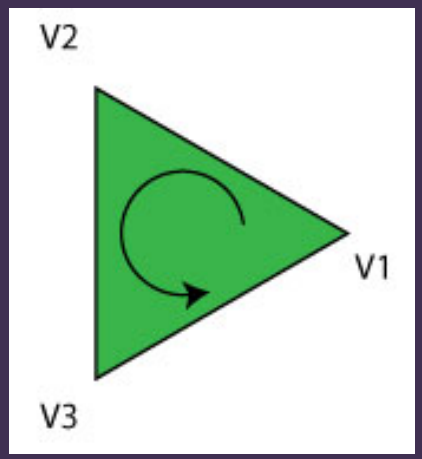

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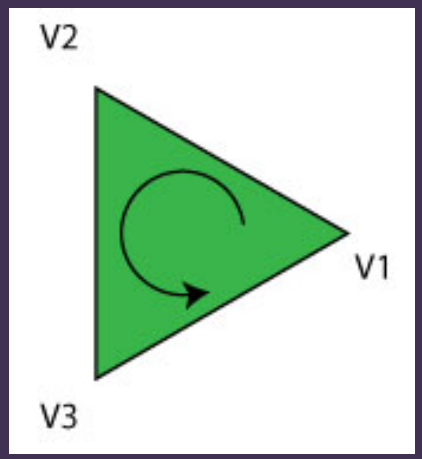

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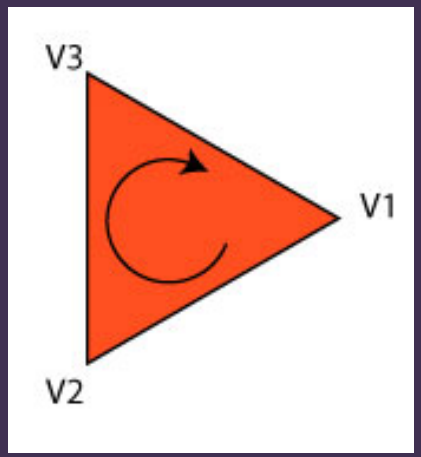

If the vertices go **clockwise**, you are looking at the **back**

Backface culling

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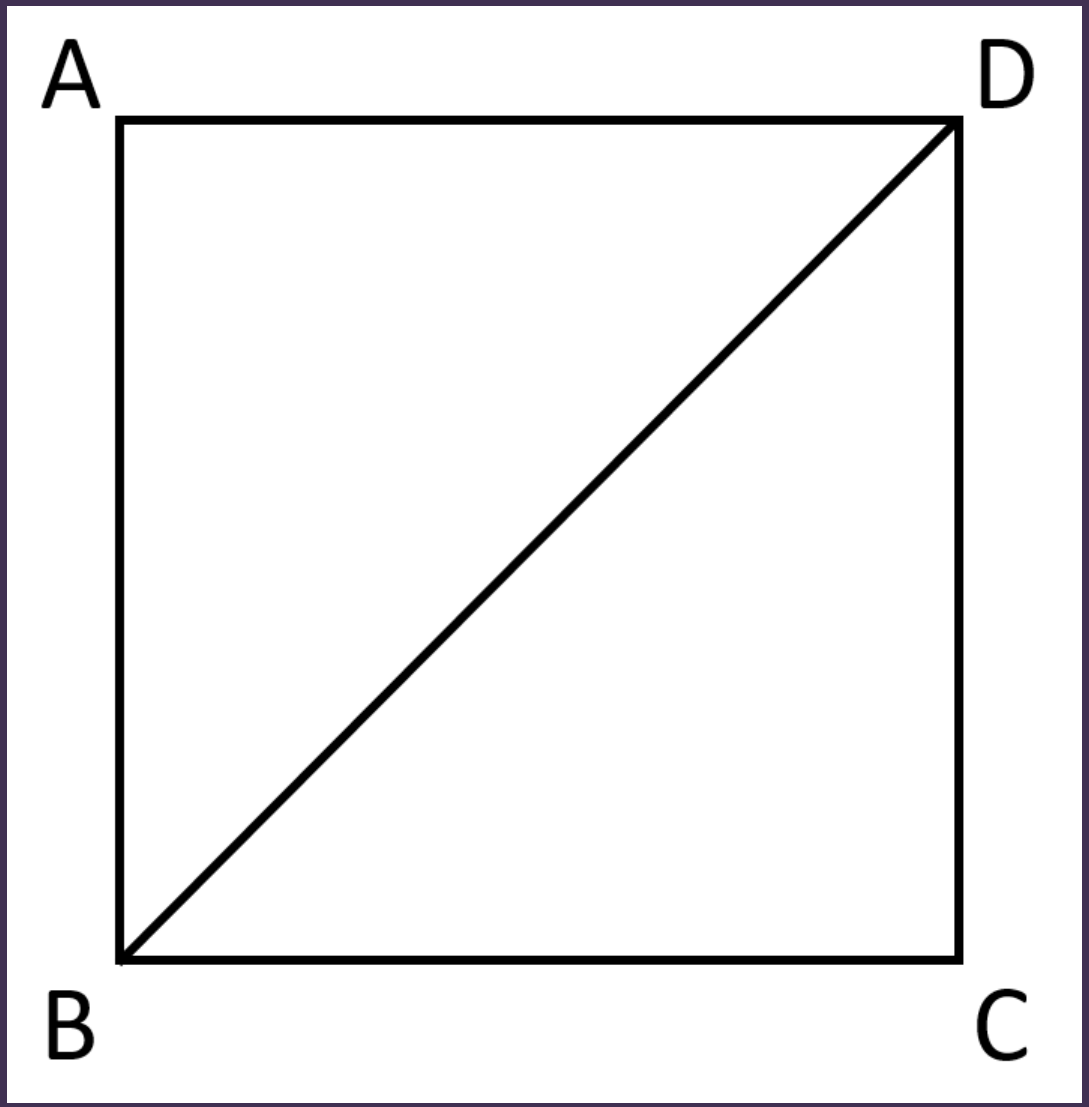
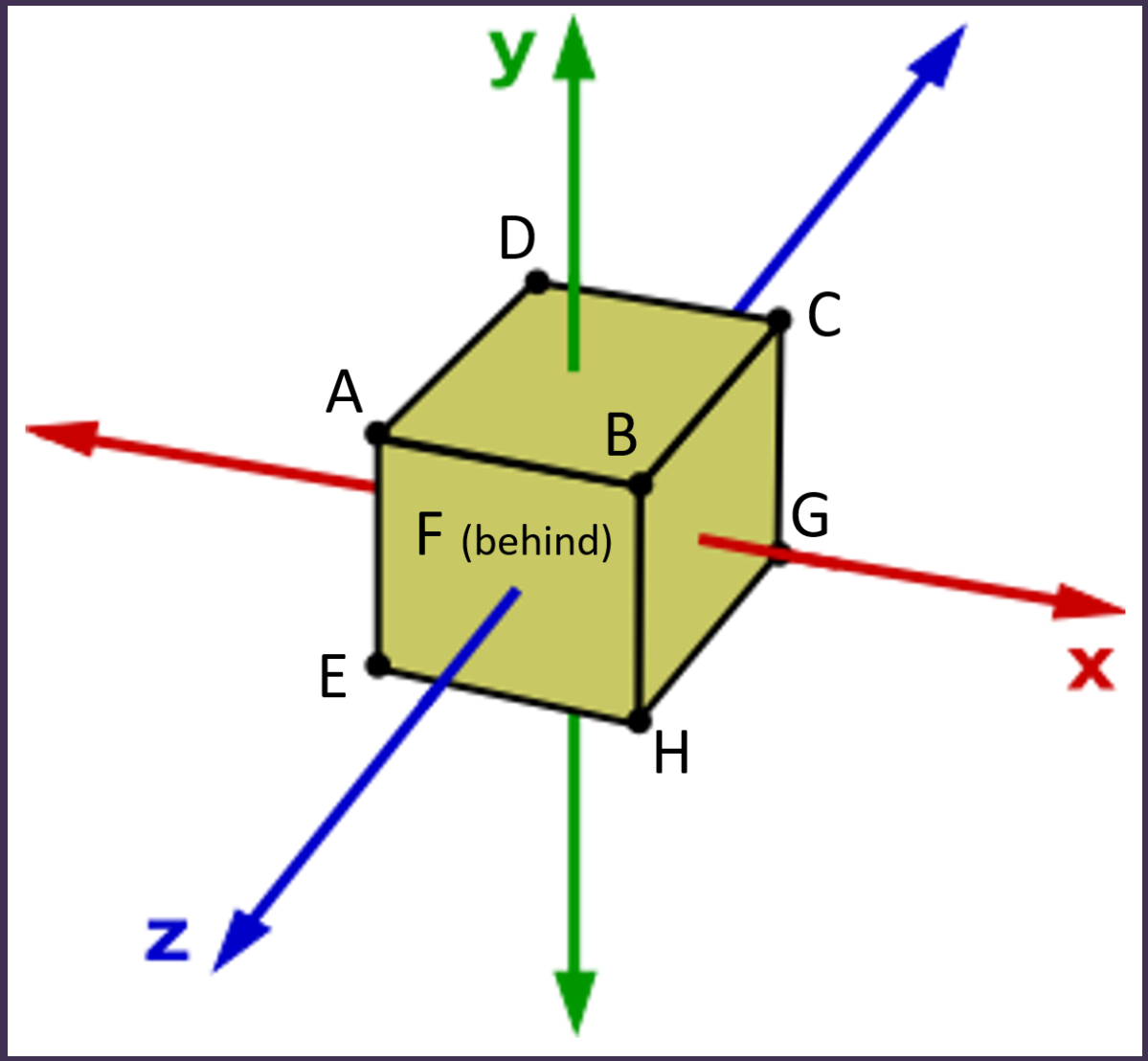
- This will cause only the front faces of triangles to be drawn
- Triangles whose front face is not visible will be **culled**
- Culled faces are not passed through the rasteriser or fragment shader
- Saves time, and should make no difference to appearance — as long as all meshes are closed and have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

When backface culling goes bad?

Let's draw a square!



Let's draw a cube!



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Vertices

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- Or we can create a **C structure** which represents a Vertex, which has member variables which represent positions, colours, normals etc
- 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);
```

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

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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

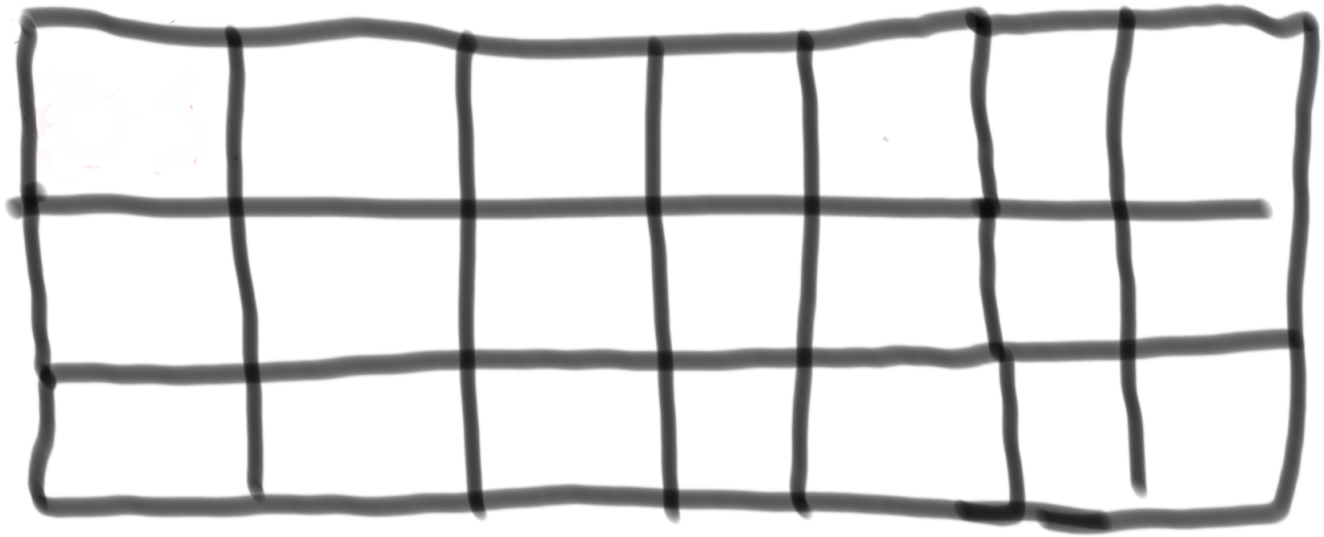
```
glEnableVertexAttribArray(0);
glVertexAttribPointer(0,3,GL_FLOAT,GL_FALSE,0,(
    void*)0);
```

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)));
```

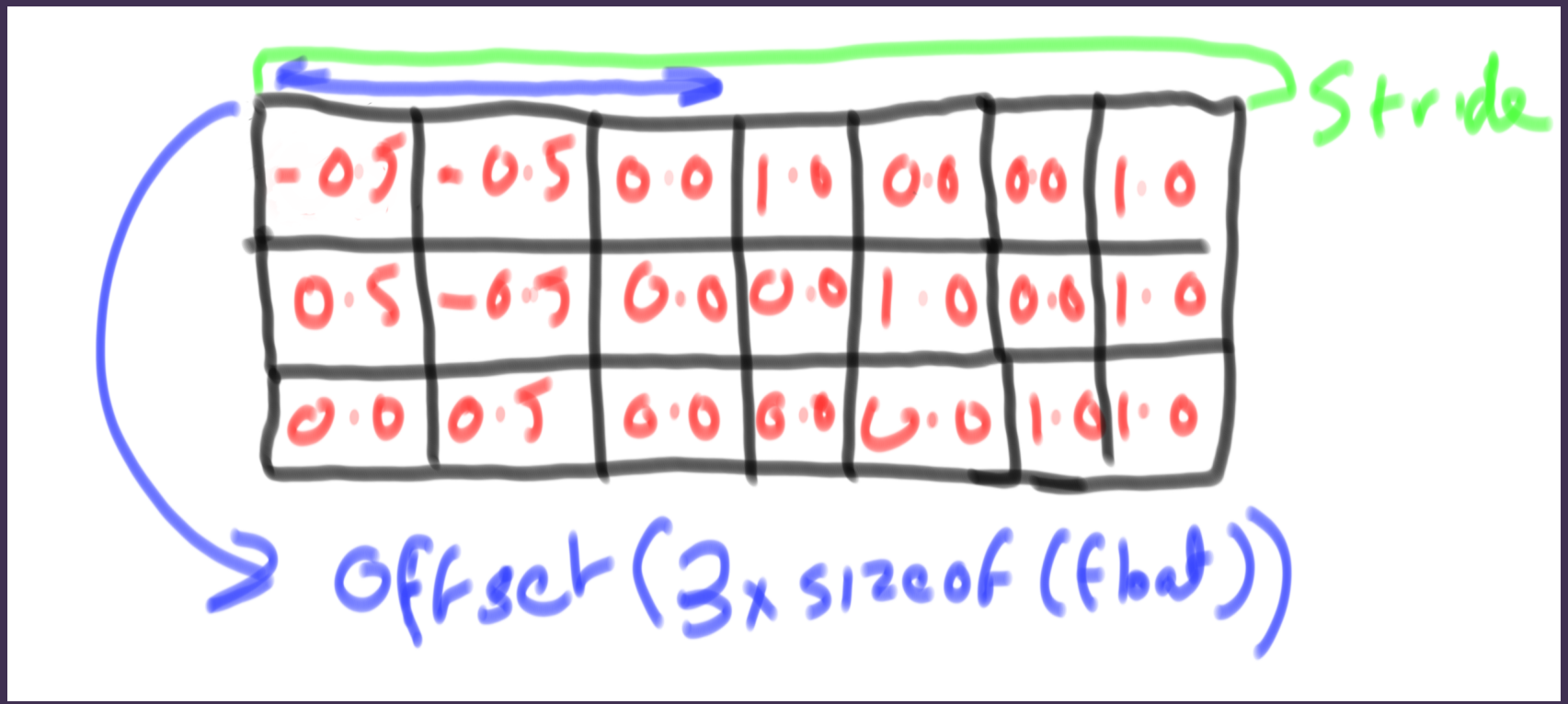
Memory and Vertex Array Object 1



Memory and Vertex Array Object 2

Memory and Vertex Array Object 3 - Stride

Memory and Vertex Array Object 3 - Offset



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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

- Finish off creating a cube using a Vertex 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/`