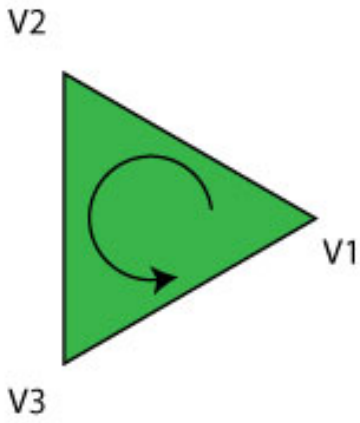
COMP220: Graphics & Simulation

4: Meshes and movement

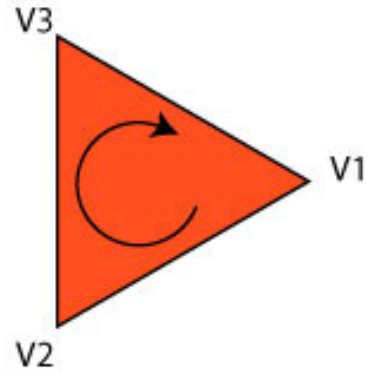
More complex meshes

Winding order

- It is sometimes important to know which side of a triangle is the "front" and which is the "back"
- OpenGL determines this by **winding order**



If the vertices go **anticlockwise**, you are looking at the **front**



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

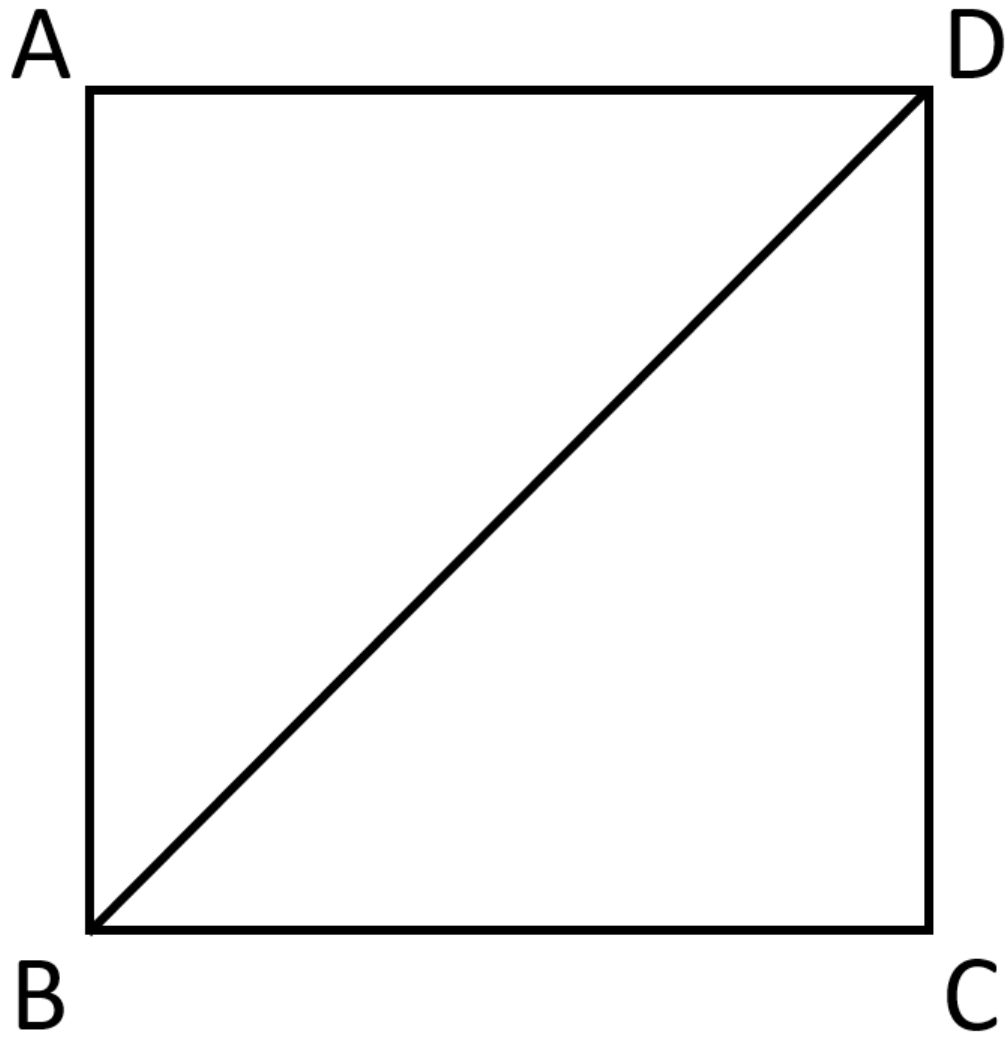
Backface culling

```
glEnable(GL_CULL_FACE);
```

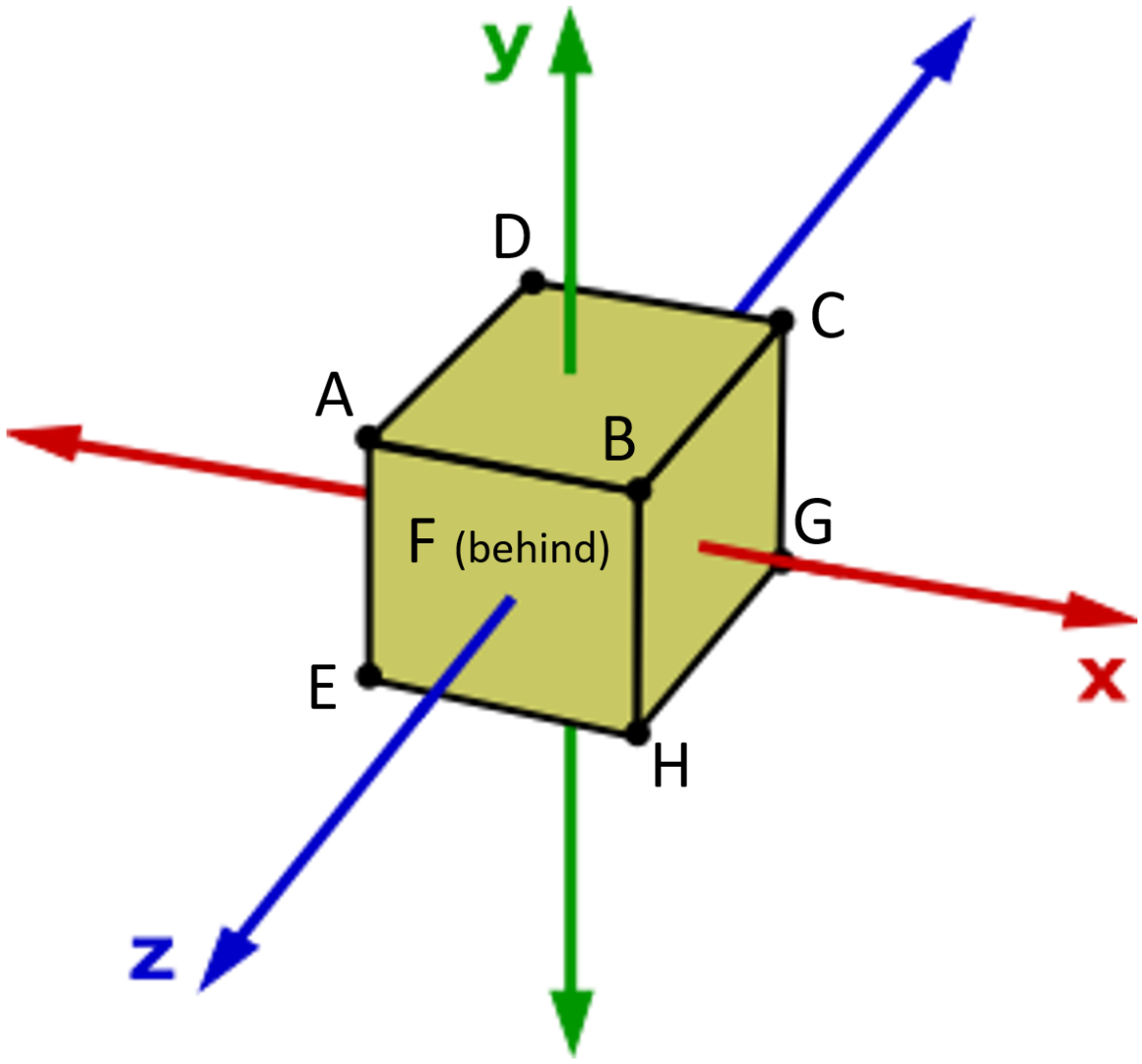
- This will cause only the front faces of triangles to be drawn
- Triangles whose front face is not visible will be **culled**
- Culled faces are not passed through the rasteriser or fragment shader
- Saves time, and should make no difference to appearance — as long as all meshes are closed and have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

When backface culling goes bad?

Let's draw a square!



Let's draw a cube!



Vertices

Interleaved Vertices

- Up until this point we have been storing vertex positions as floats
- If we need a vertex to have colours, we can store these in a separate Vertex Buffer
- 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

- There will be a slight change to our vertex buffer
- 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

- 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

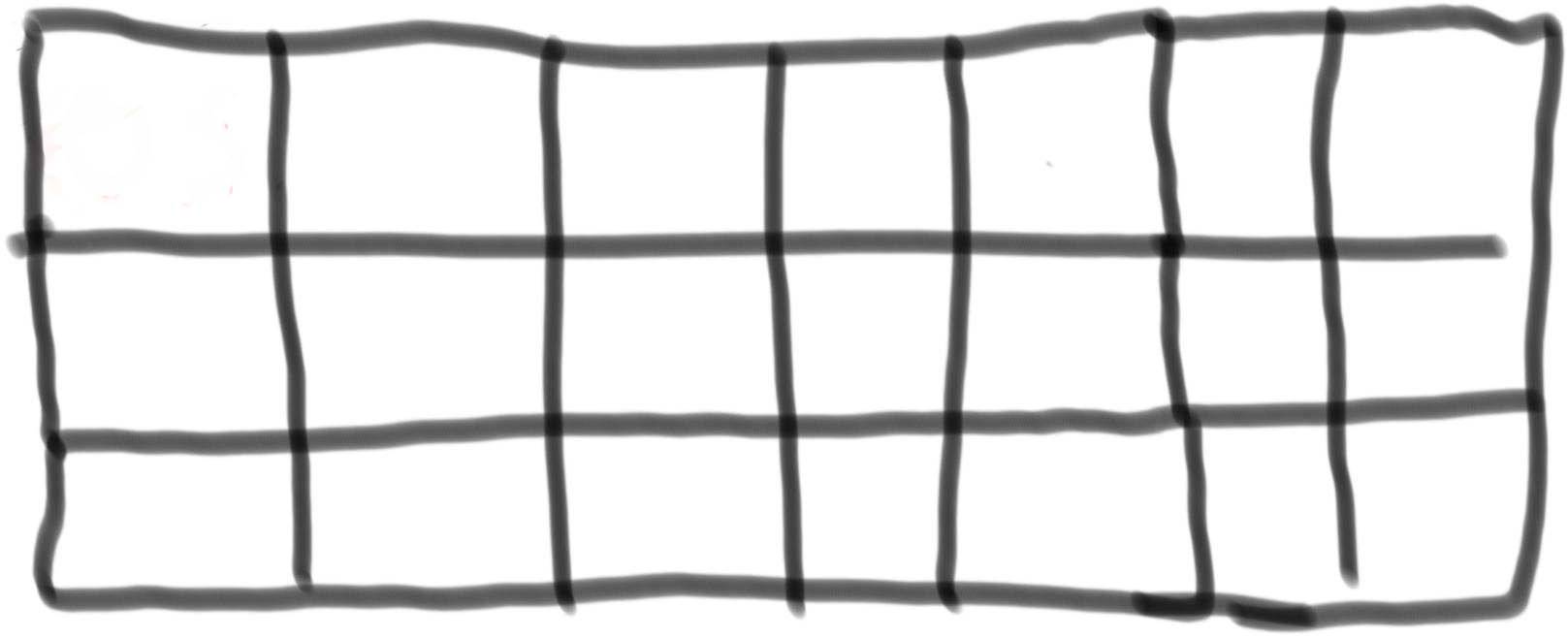
```
    glEnableVertexAttribArray(0);
    glVertexAttribPointer(0,3,GL_FLOAT,GL_FALSE,0,( ↩
        void*)0);
```

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

Element Buffer

Element Buffer

- If we look at the cube sample, we are sending 36 vertices
- 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