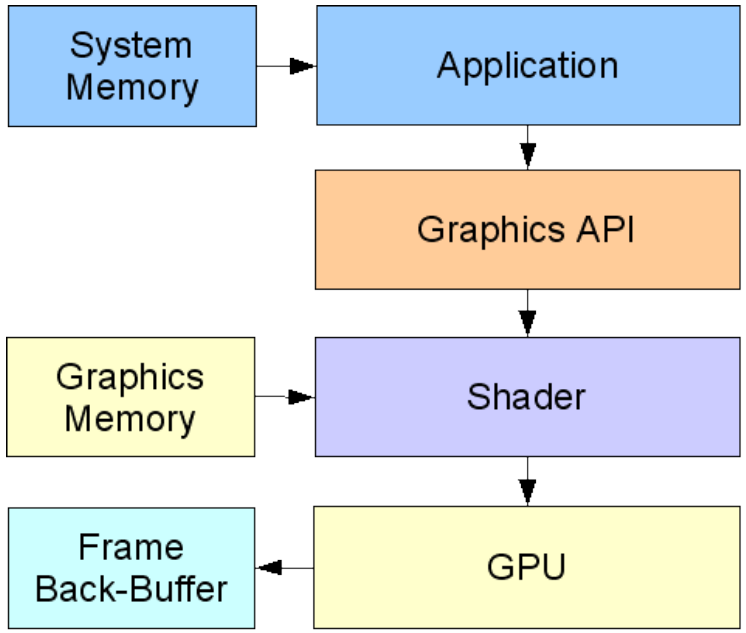
CSE4204
LAB-1 : Intro to WebGL

Graphics API

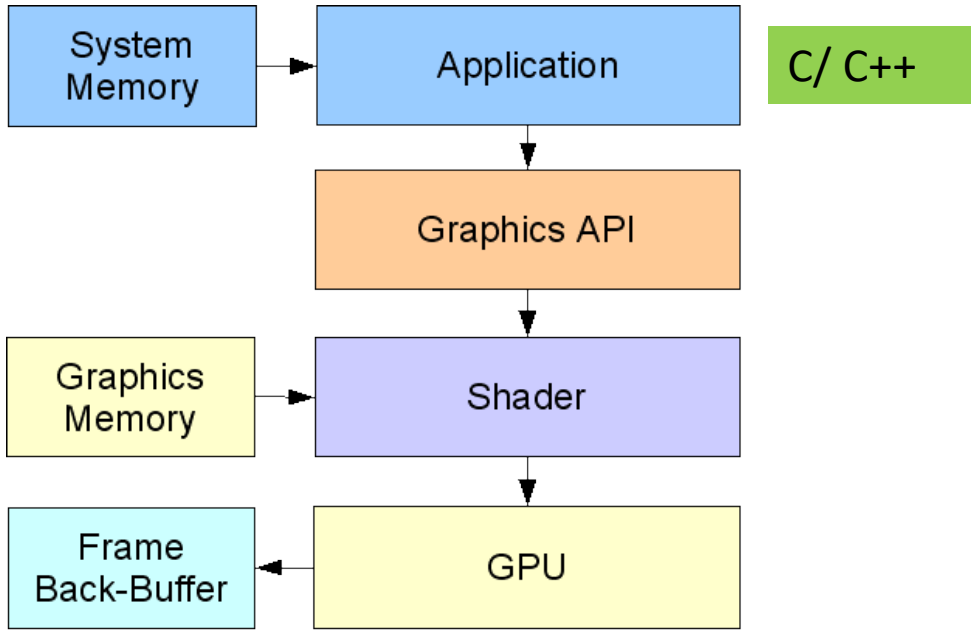
- Example: OpenGL, WebGL, Direct3D, etc.

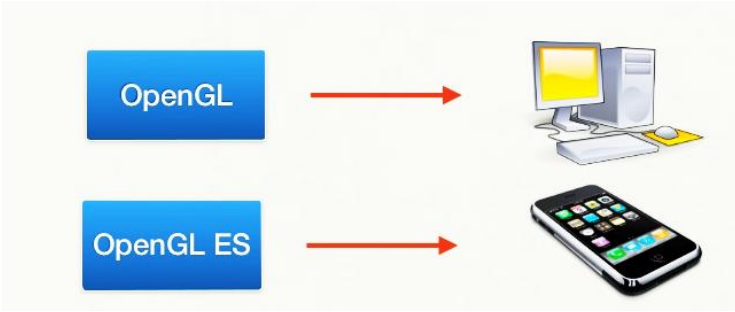


Source: https://ict.senecacollege.ca/~chris.szalwinski/archives/gam670.071/content/shadr_p.html

OpenGL

- OpenGL and OpenGL ES

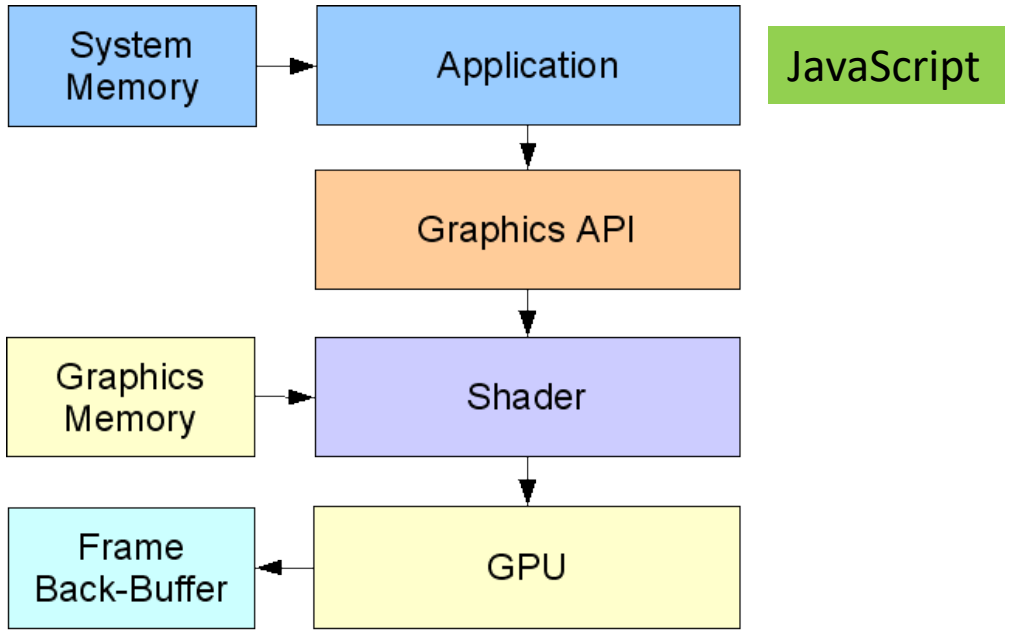




Source: https://ict.senecacollege.ca/~chris.szalwinski/archives/gam670.071/content/shadr_p.html

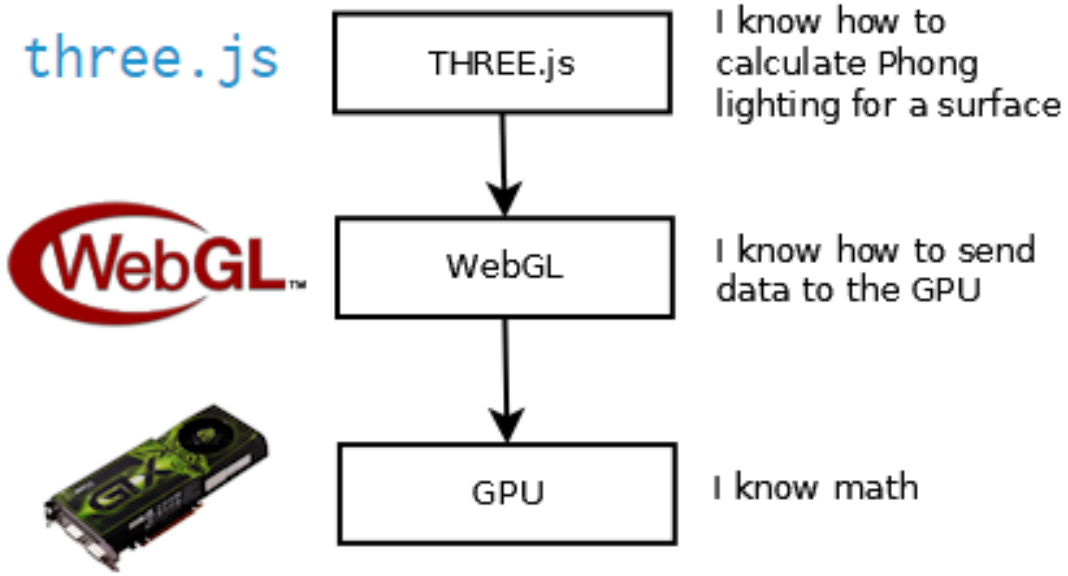
WebGL

- a JavaScript interface for OpenGL-ES-2.x API, promoted by Khronos.



Source: https://ict.senecacollege.ca/~chris.szalwinski/archives/gam670.071/content/shadr_p.html

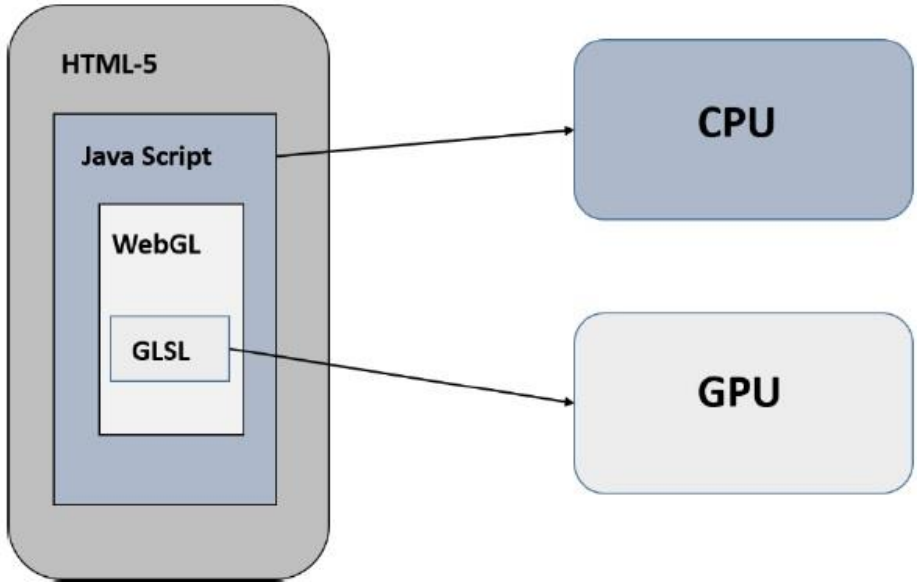
WebGL



Source: https://cglearn.codelight.eu/pub/computer-graphics/computer-graphics

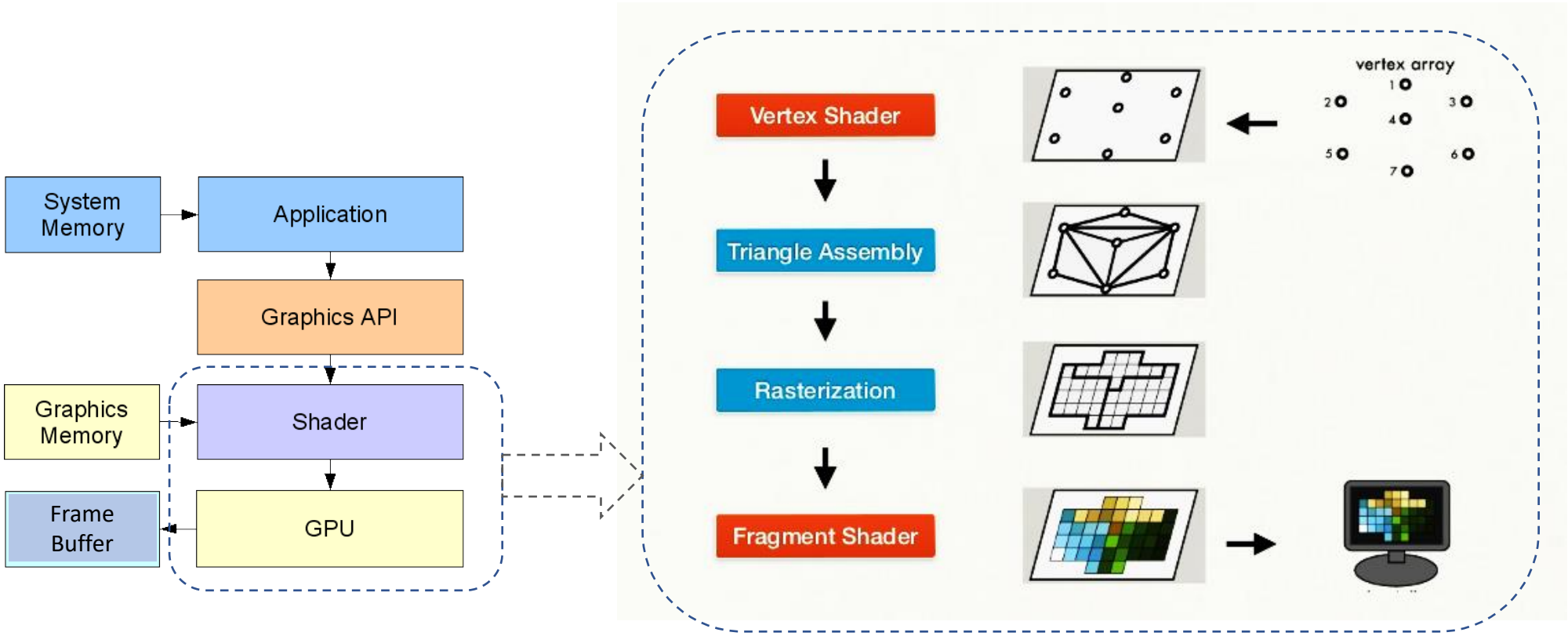
A WebGL Program

- There are two sides to any WebGL program:
  - Part – 1: written in JavaScript
  - Part – 2: written in GLSL, a language for writing "shader" programs that run on the GPU.



Source: http://math.hws.edu/graphicsbook
Source: https://www.tutorialspoint.com/webgl/webgl_quick_guide.htm

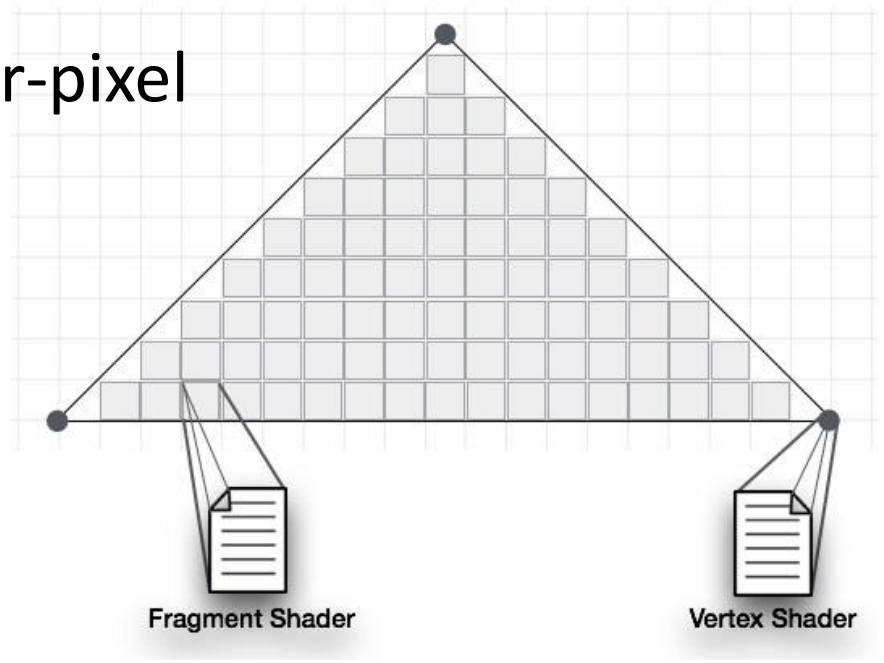
A Graphics Pipeline



Source: https://pt.slideshare.net/senchainc/webgl-fundamentals-10013633/12

Shaders

- Vertex Shader: Per-vertex
- Fragment Shader: Per-fragment/ per-pixel



Source: https://www.tutorialspoint.com/webgl/webgl_quick_guide.htm

A Shader Program

References:

- https://www.tutorialspoint.com/webgl/webgl_drawing_points.htm
- http://math.hws.edu/graphicsbook/index.html

Steps*

Get the code: https://rb.gy/cpf3uo

- Step 1 – Prepare the canvas and get WebGL rendering context
- Step 2 – Create and compile Shader programs
- Step 3 – Associate the shader programs with buffer objects
- Step 4 – Define the geometry and store it in buffer objects
- Step 5 – Drawing the required object

Modified from the source: https://www.tutorialspoint.com/webgl/webgl_drawing_points.htm
*Can be altered

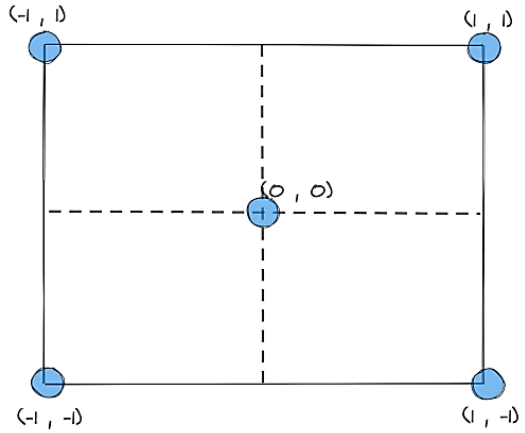
```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
   `attribute vec3 a_coords;
    void main() {
        gl_Position = vec4(a_coords, 1.0);
    }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 1: Canvas and WebGL rendering context

```
<canvas
id="webglcanvas" width="500" height="500">
</canvas>
```

```
var canvas = document.getElementById("webglcanvas");
```

```
var  gl = canvas.getContext("webgl");
```




```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
   `attribute vec3 a_coords;
    void main() {
        gl_Position = vec4(a_coords, 1.0);
    }`;


var fragmentShaderSource =
   `void main() {
        gl_FragColor = vec4(1.0, 0.0, 0.0, 1.0);
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var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

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gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 1: Background and reset buffer

```
gl.clearColor(0.75, 0.75, 0.75, 1.0);

gl.clear(gl.COLOR_BUFFER_BIT);
```

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
    `attribute vec3 a_coords;
     void main() {
         gl_Position = vec4(a_coords, 1.0);
     }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
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var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

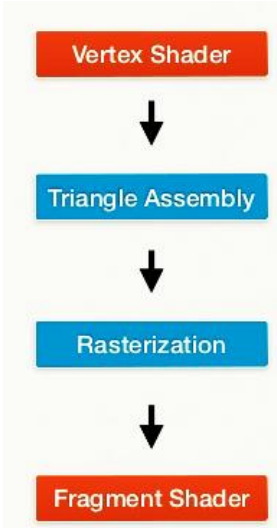
Step – 2: Vertex Shader

```
var vertexShaderSource =

`attribute vec3 a_coords;
 void main() {
     gl_Position = vec4(a_coords, 1.0);
         }`;
```

vertices

Clipping




```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
   `attribute vec3 a_coords;
    void main() {
        gl_Position = vec4(a_coords, 1.0);
    }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
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gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

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gl.useProgram(prog);

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                                0.5, 0.0, 0.0] );

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gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```
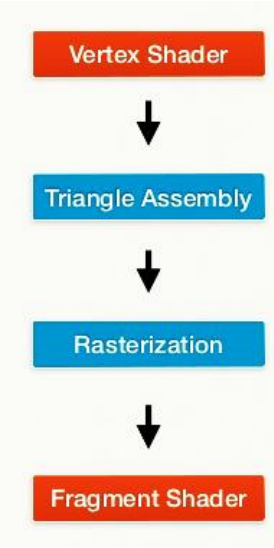

Step – 2: Vertex Shader

```
var vertexShaderSource =

`attribute vec3 a_coords;
 void main() {
     gl_Position = vec4(a_coords, 1.0);
             }`;
```

Per-vertex




```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
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var vertexShaderSource =
   `attribute vec3 a_coords;
    void main() {
        gl_Position = vec4(a_coords, 1.0);
    }`;


var fragmentShaderSource =
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gl.compileShader( vsh );

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gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

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var a_coords_location = gl.getAttribLocation(prog, "a_coords");

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                                0.5, 0.0, 0.0] );

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gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```
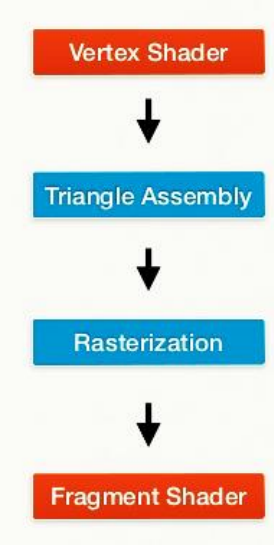

Step – 2: Fragment Shader

```
var fragmentShaderSource =

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

Colored pixels




```
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var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
    `attribute vec3 a_coords;
     void main() {
         gl_Position = vec4(a_coords, 1.0);
     }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 2: Create and Compile Shaders

```
var vsh = gl.createShader( gl.VERTEX_SHADER );

gl.shaderSource( vsh, vertexShaderSource );

gl.compileShader( vsh );
```

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
   `attribute vec3 a_coords;
    void main() {
        gl_Position = vec4(a_coords, 1.0);
    }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 2: Create and Compile Shaders

```
var fsh = gl.createShader( gl.FRAGMENT_SHADER );

gl.shaderSource( fsh, fragmentShaderSource );

gl.compileShader( fsh );
```

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
    `attribute vec3 a_coords;
     void main() {
         gl_Position = vec4(a_coords, 1.0);
     }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 2: Link shaders and use program

```
var prog = gl.createProgram();

gl.attachShader( prog, vsh );

gl.attachShader( prog, fsh );

gl.linkProgram( prog );

gl.useProgram(prog);
```

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
    `attribute vec3 a_coords;
     void main() {
         gl_Position = vec4(a_coords, 1.0);
     }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 3: Associate Shaders

```
var a_coords_location =
        gl.getAttribLocation(prog, "a_coords");
```

```
attribute vec3 a_coords;
void main() {
        gl_Position = vec4(a_coords, 1.0);
        }
```

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
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var vertexShaderSource =
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     void main() {
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     }`;


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    `void main() {
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gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```
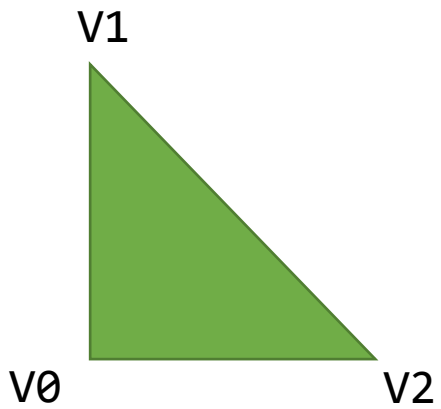

Step – 4: Define Geometry

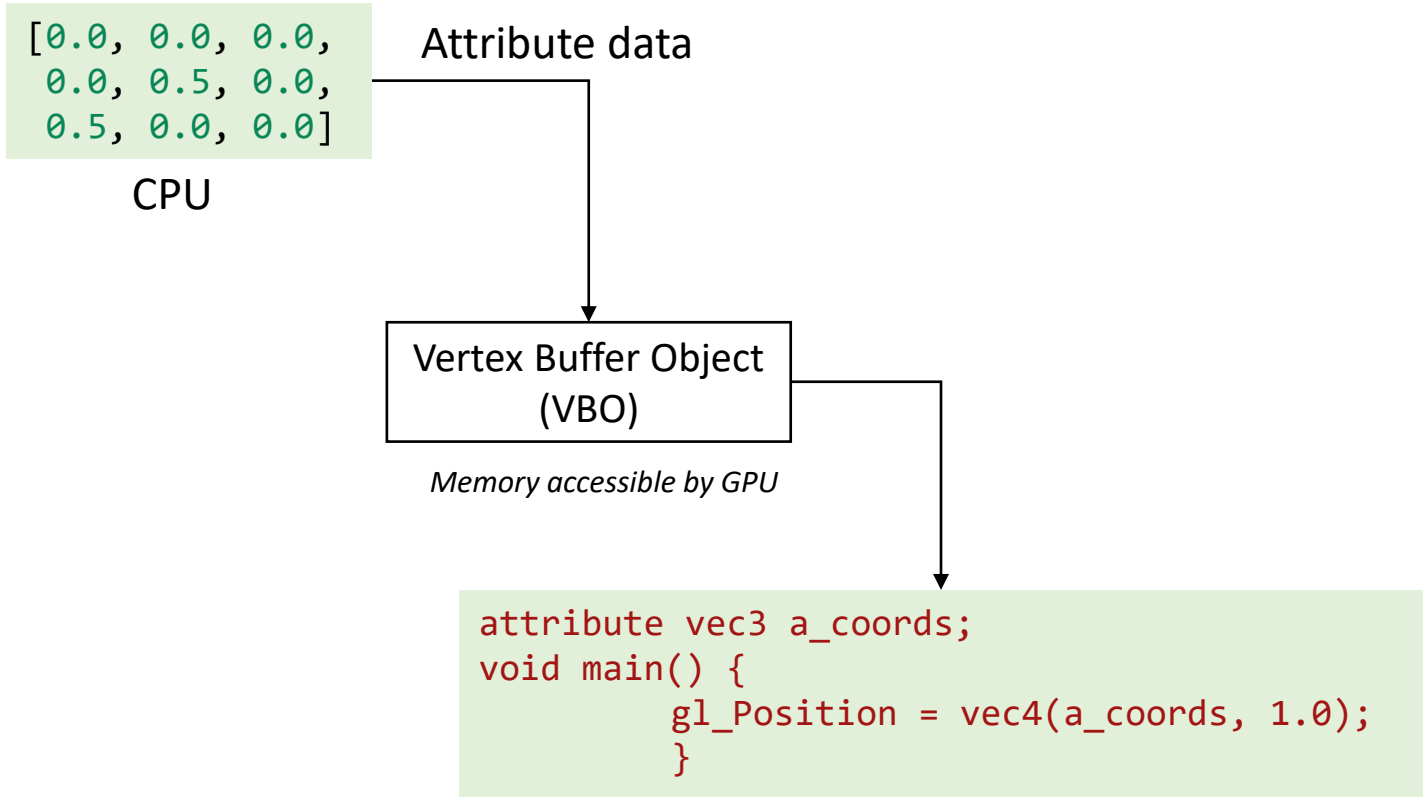
```
var coords = new Float32Array( [0.0, 0.0, 0.0, \\V0
                                0.0, 0.5, 0.0, \\V1
                                0.5, 0.0, 0.0] \\V2
                             );
```




```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
   `attribute vec3 a_coords;
    void main() {
        gl_Position = vec4(a_coords, 1.0);
    }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 4: Vertex Buffer Objects

```
var a_coords_buffer = gl.createBuffer();
```




```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
    `attribute vec3 a_coords;
     void main() {
         gl_Position = vec4(a_coords, 1.0);
     }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 4: Vertex Buffer Objects (VBOs)

```
gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
```

will be used for attribute

It specifies how the VBO will be used.

```
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
```

same data will be used

```
gl.vertexAttribPointer(a_coords_location, 3,
                       gl.FLOAT, false, 0, 0);
```

For 3D data (x,y,z)

```
gl.enableVertexAttribArray(a_coords_location);
```

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
   `attribute vec3 a_coords;
    void main() {
        gl_Position = vec4(a_coords, 1.0);
    }`;


var fragmentShaderSource =
   `void main() {
        gl_FragColor = vec4(1.0, 0.0, 0.0, 1.0);
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var vsh = gl.createShader( gl.VERTEX_SHADER );
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gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

Step – 5: Draw Required Objects

```
gl.drawArrays(gl.TRIANGLES, 0, 3);
```

primitives

Start vertex

Number of vertices

```
[0.0, 0.0, 0.0, → 0
 0.0, 0.5, 0.0, → 1
 0.5, 0.0, 0.0] → 3
```

```
var canvas = document.getElementById("webglcanvas");
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gl.clear(gl.COLOR_BUFFER_BIT);

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    `attribute vec3 a_coords;
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gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```
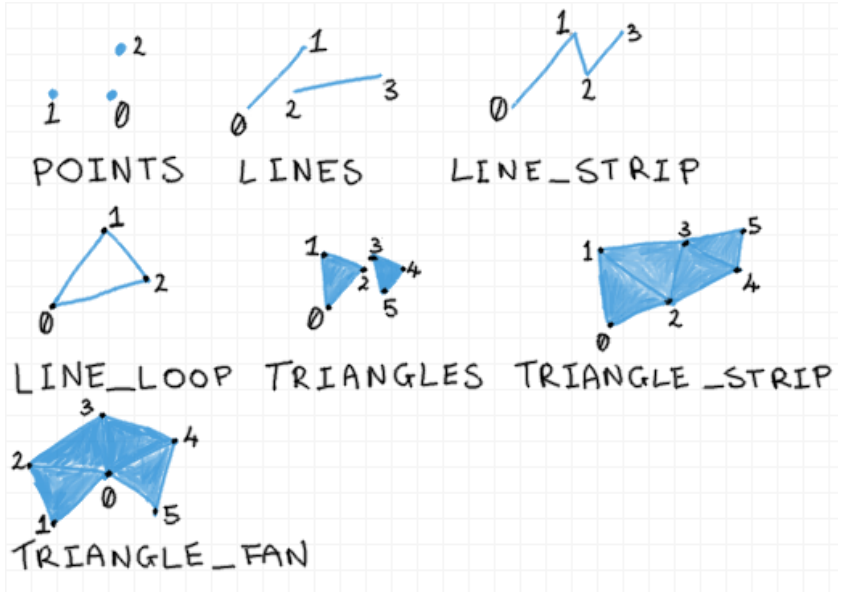

Primitives

```
gl.drawArrays(gl.TRIANGLES, 0, 3);
```



Source: https://antongerdelan.net/opengl/vertexbuffers.html

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

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    `attribute vec3 a_coords;
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gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```
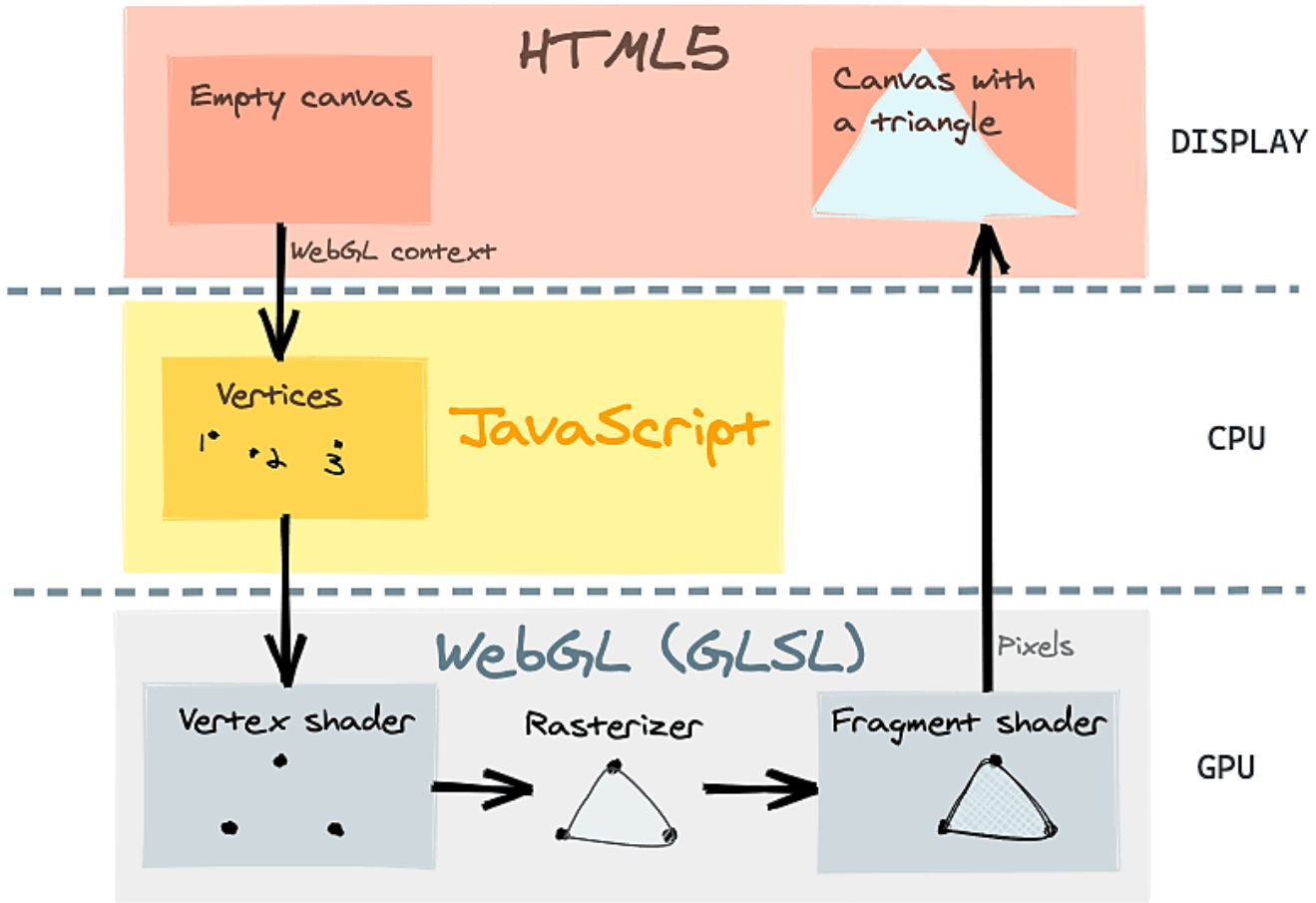

Full Code



Source: https://www.h5w3.com/44328.html

```
var canvas = document.getElementById("webglcanvas");
var  gl = canvas.getContext("webgl");

gl.clearColor(0.75, 0.75, 0.75, 1.0);
gl.clear(gl.COLOR_BUFFER_BIT);

var vertexShaderSource =
    `attribute vec3 a_coords;
     void main() {
         gl_Position = vec4(a_coords, 1.0);
     }`;


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

var vsh = gl.createShader( gl.VERTEX_SHADER );
gl.shaderSource( vsh, vertexShaderSource );
gl.compileShader( vsh );

var fsh = gl.createShader( gl.FRAGMENT_SHADER );
gl.shaderSource( fsh, fragmentShaderSource );
gl.compileShader( fsh );

var prog = gl.createProgram();

gl.attachShader( prog, vsh );
gl.attachShader( prog, fsh );
gl.linkProgram( prog );
gl.useProgram(prog);

var a_coords_location = gl.getAttribLocation(prog, "a_coords");

var coords = new Float32Array( [0.0, 0.0, 0.0,
                                0.0, 0.5, 0.0,
                                0.5, 0.0, 0.0] );

var a_coords_buffer = gl.createBuffer();

gl.bindBuffer(gl.ARRAY_BUFFER, a_coords_buffer);
gl.bufferData(gl.ARRAY_BUFFER, coords, gl.STATIC_DRAW);
gl.vertexAttribPointer(a_coords_location, 3, gl.FLOAT, false, 0, 0);
gl.enableVertexAttribArray(a_coords_location);
gl.drawArrays(gl.TRIANGLES, 0, 3);
```