JavaScript and WebGL 1

CS425: Computer Graphics I

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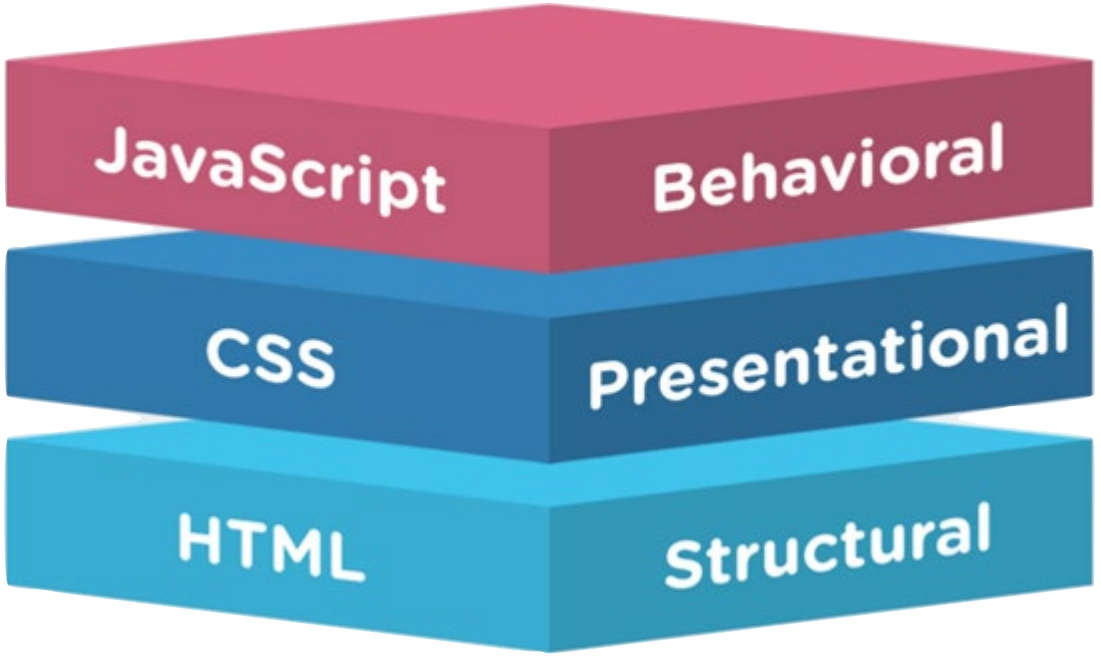
Overview

- Web technologies
- Web environment
- JavaScript
- WebGL

Web technologies

Web technologies



- **JavaScript**: manage user interaction with the structure and presentation.
- **CSS**: manage presentation
- **HTML5**: mark-up language to structure the content of web pages.

HTML: First example

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <title>First example</title>
</head>
<body>

Content here

</body>
</html>
```

Elements:
<element>
</element>

Examples:
html, head, body

HTML: First example

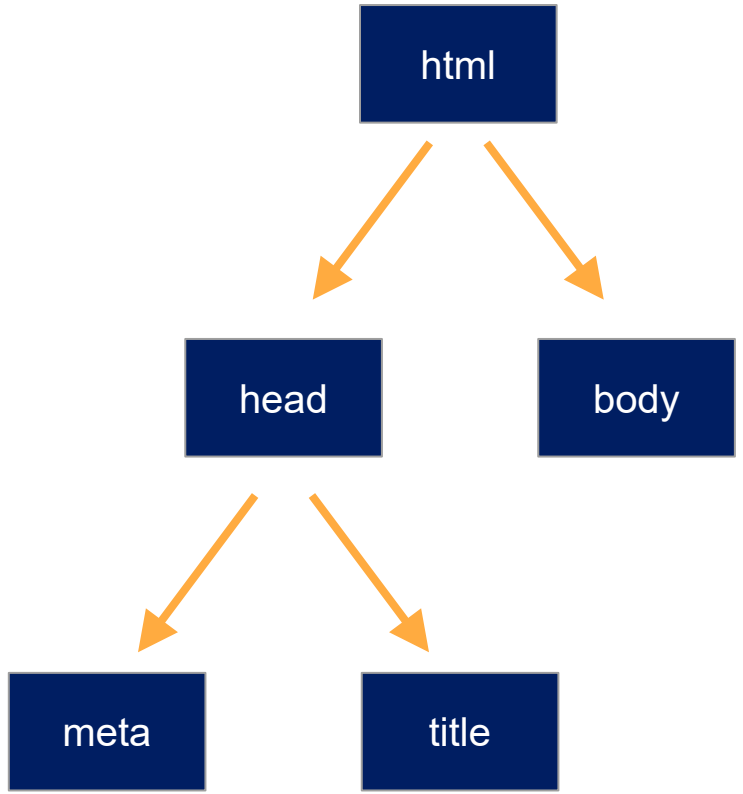
```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <title>First example</title>
</head>
<body>

Content here

</body>
</html>
```

Attributes:
<… attribute=“”>

Examples:
lang, charset, id

HTML: First example

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <title>First example</title>
</head>
<body>

Content here

</body>
</html>
```



HTML: Elements and attributes

Main root: <html>

Metadata: <base>, <head>, <link>, <meta>, <style>, <title>

Root: <body>

Content sectioning: <address>, <main>, …, <head>

Text content: , <figure>, <hr>,

Image and multimedia: <audio>, <img>, …, <video>

Scripting: <canvas>, <script>

…

Cascading Style Sheets (CSS)

```
body {
    margin: 10px;
    font-size: 20px;
}
```

Selectors:
selector {
    …
}

Examples:
body, #first, .special

Cascading Style Sheets (CSS)

Different selectors

```
h1, h2  {
    ...
}

.classe p {
    ...
}
```

```
div > p  {
    ...
}

#id1 ~ #id2 {
    ...
}
```

```
div[attr]  {
    ...
}

div[attr="val"] {
    ...
}
```

Cascading Style Sheets (CSS)

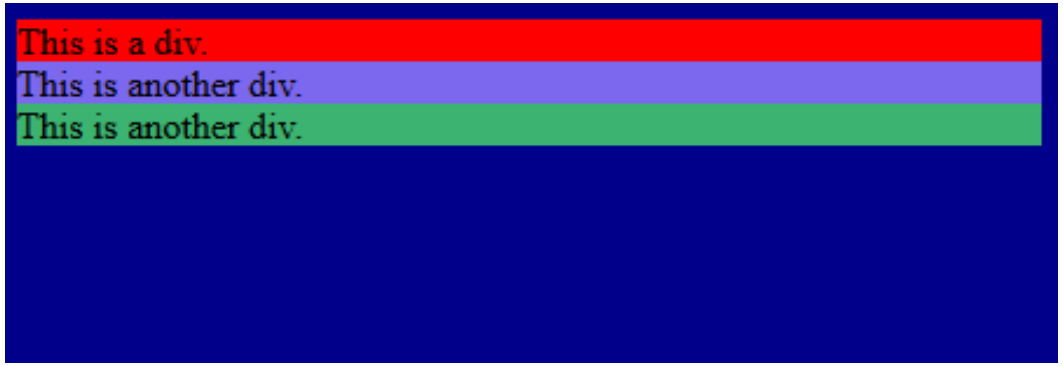
```
body {
    margin: 10px;
    font-size: 20px;
}
```

Properties:
key: value;

Examples:
margin, color, font-size

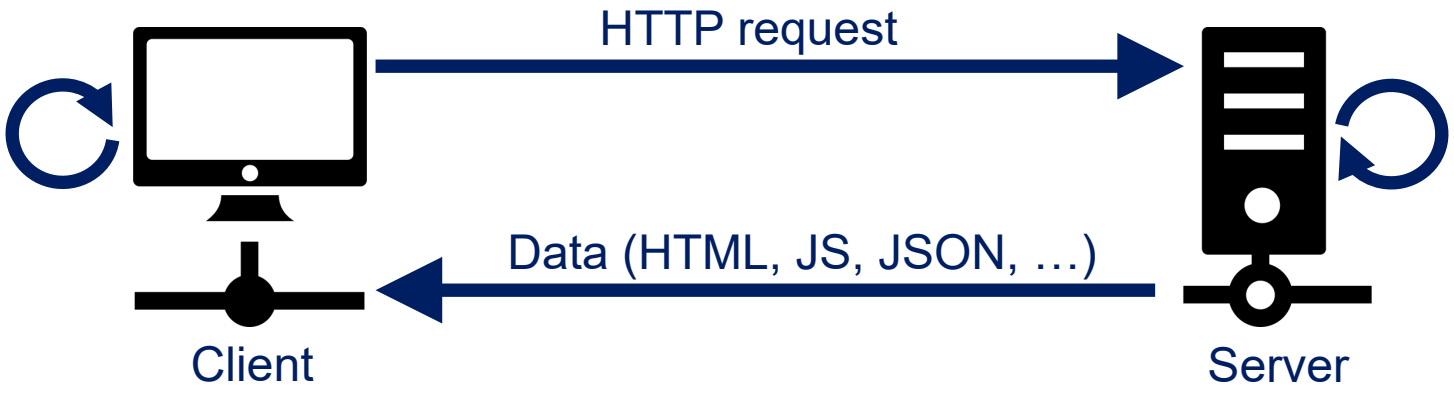
Putting it all together

```
<!DOCTYPE html>
<html lang="en">
<head>
    <title>First example</title>
</head>
<style>
    body { background-color: darkblue;}
    div { background-color: mediumslateblue;}
    #mydiv { background-color: red;}
    .myclass { background-color: mediumseagreen;}
</style>
<body>
    <div id="mydiv">This is a div.</div>
    <div id="myseconddiv">This is another div.</div>
    <div class="myclass">This is another div.</div>
</body>
</html>
```



Client and server

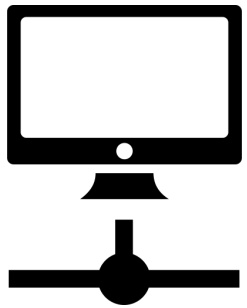
Client-side:
- Rendering
- Interaction
- Light-weight aggregation
- Filtering



Server-side:
- Database query
- Feature extraction
- Data mining

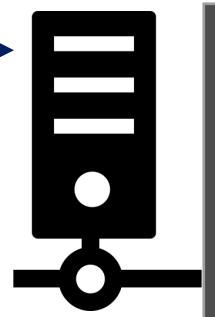
Client and server

Application



HTTP request

Data



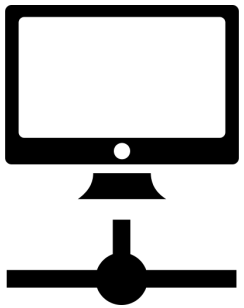
HTTP Server

- Serve HTML, JS, CSS files
- Serve geometries
- Compute tiles
- Extract features

- HTML, JS, CSS files
- Geometry files
- Tiles
- Features

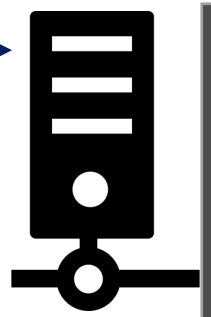
CS425: Client and server

Application



HTTP request

Data



HTTP Server

Serve HTML, JS, CSS files

Serve geometries

Compute tiles

Extract features

HTML, JS, CSS files

Geometry files

Tiles

Features

CS425: Client and server

```
example@DESKTOP MINGW64 ~/example
$ python -m http.server
Serving HTTP on 0.0.0.0 port 8000 (http://0.0.0.0:8000/) ...
```

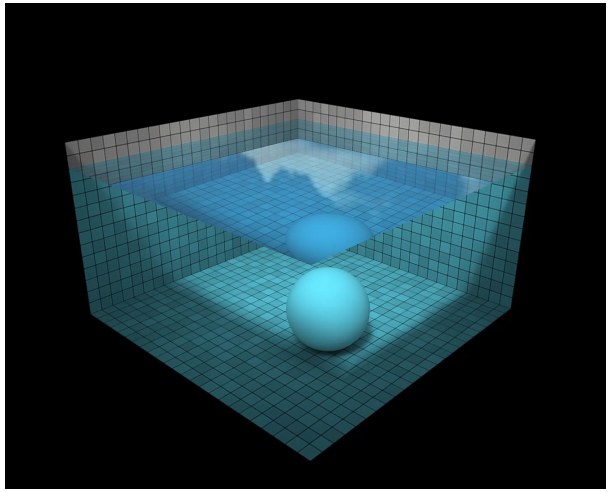
Detailed steps: https://mzl.la/3bSLff0

JavaScript: a client-side programming language

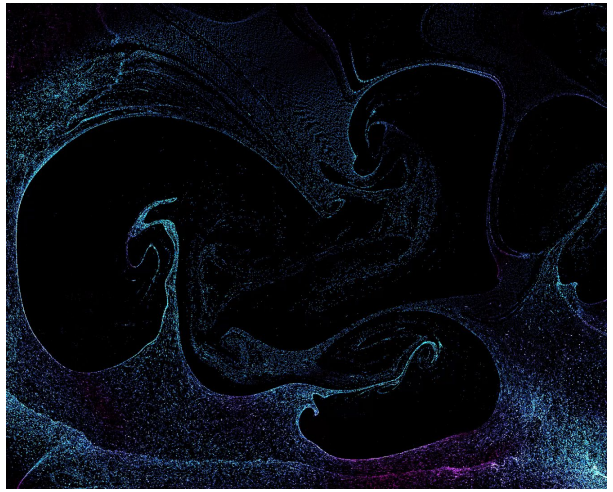
- Interpreted object-oriented language.
- Loosely typed language.
  - Does not require a variable type to be specified.
- Add, delete, and modify nodes from the document tree.
- Integration with other frameworks and toolkits:
  - Qt
  - Swift

JavaScript: a client-side programming language

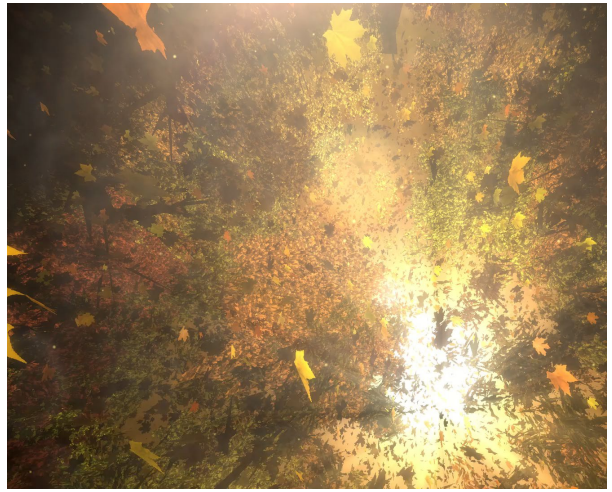
- Is JavaScript slow?
  - JavaScript engines in browsers are getting much faster.
  - Not an issue for graphics, since we transfer the data to the GPU with WebGL.



http://madebyevan.com/webgl-water/



https://haxiomic.github.io/projects/webgl-fluid-and-particles/



http://oos.moxiecode.com/js_webgl/autumn/

JavaScript basics

- Two scopes:
  - Local
  - Global
- Variable created inside a function with ‘var’ keyword: local to function.
  - Created and destroyed every time function is called.
  - BUT: variables declared without ‘var’ keyword are always global.
- Variable created outside a function: global

JavaScript basics

- Inserting JavaScript code in a web page:
  - Inside an HTML tag script.
  - In an external file.
  - As an HTML attribute value.

```
<script type="text/javascript">
    alert("Here is an example.");
</script>
```

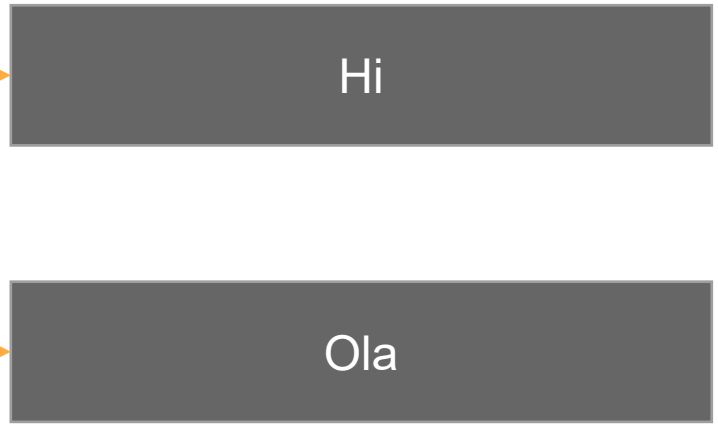
```
<script type="text/javascript“ src="file.js"></ script>
```

Statements, comments, and variables

- Statements: separated by new line or semicolon.
- Comment:
  - Single line: // here is a comment
  - Multi line: /* here is a comment */
- Loops and iteration:
  - for, for…in, for…of, do…while, while.
- Variables:
  - Assignment operator (=) to assign values.

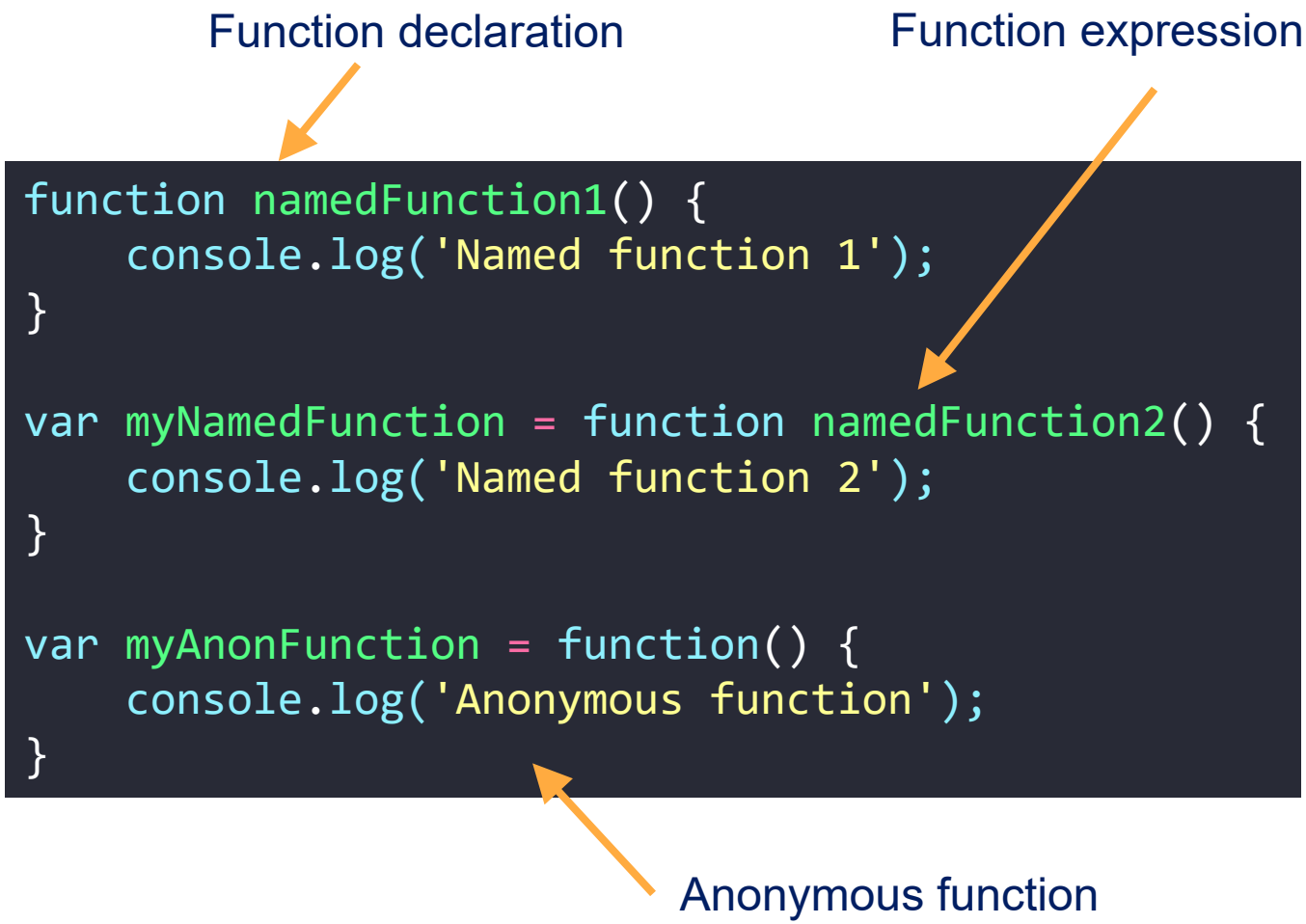
Variable scope

```
var message = 'Hi';

function modify1(){
    var message = 'Hello';
}

function modify2(){
    message = 'Ola';
}

modify1();
console.log(message);

modify2();
console.log(message);
```



Functions

- Different ways to define functions:
  - Named
  - Anonymous
- Function expressions cannot be used before they appear in the code.



Functions

- Function declarations load before any code is executed, while function expressions load only when the interpreter reaches that line.
- Function expressions: closures, arguments to other functions

```
alert(foo());
function foo() { return 5; }
```

Function declaration: error in this case, as foo wasn't loaded yet.

```
alert(foo());
var foo = function() { return 5; }
```

Function expression: alerts 5. Declarations are loaded before any code can run.

Functions

- Functions are first-class objects:
  - Supports passing functions to other functions.
  - Returning them as values from other functions.
  - Assigning them to variables or data structures.
- Closure:
  - Function that maintains the local variables of a function, after the function has returned.

Closure example

```
function sayHi(name){
    var whatToSay = 'Hi '+name;

   return function(){
        console.log(whatToSay);
    }
}

var say = sayHi('Bob');
say();
```

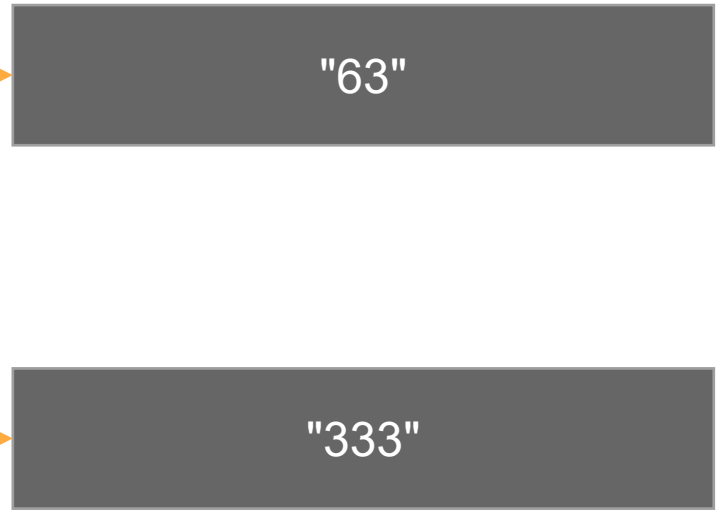
A closure: a function inside a function

No matter where it is executed, closure function will always remember variables from sayHi.

Data types: numbers and strings

- Numbers: a primitive data type (32-bit float).
- String: sequence of characters.
- Booleans.

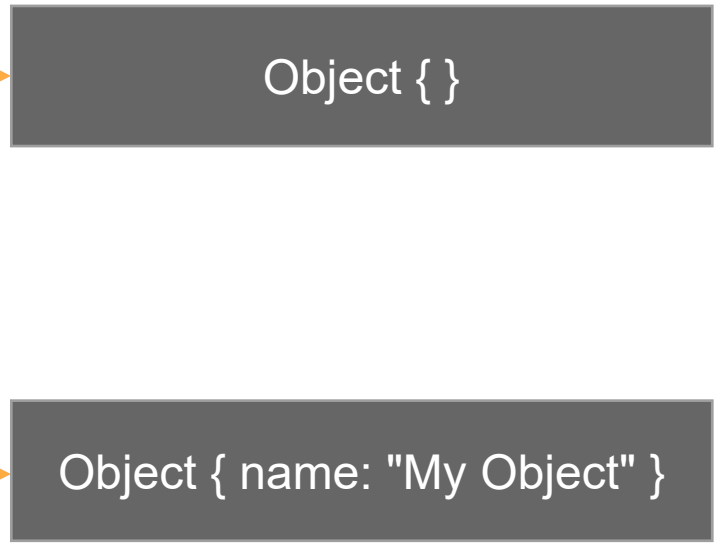
```
var aux1 = 3.0;
var aux2 = 3;
var aux3 = '3’;

console.log(aux1+aux2+aux3);
console.log(aux3+aux2+aux1);
```



Objects

- In JavaScript, objects are a collection of properties with a name and a value.

```
var myObject = new Object();
console.log(myObject);

myObject.name = "My Object";
console.log(myObject);
```



Arrays

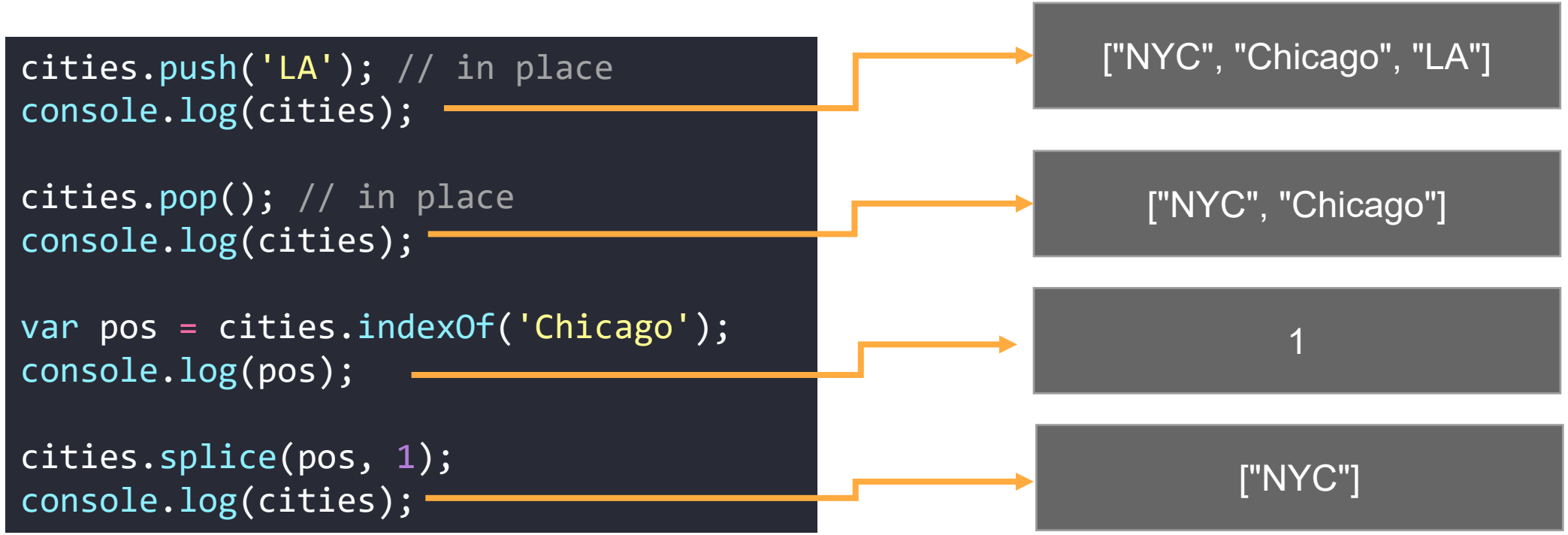
- List-like objects.

```
var cities = ['NYC', 'Chicago'];

console.log(cities[0]);
console.log(cities[cities.length-1]);

cities.forEach(function(item, index)) {
    console.log(item, index);
}
```

Arrays

- List-like objects.

```
cities.push('LA'); // in place
console.log(cities);

cities.pop(); // in place
console.log(cities);

var pos = cities.indexOf('Chicago');
console.log(pos);

cities.splice(pos, 1);
console.log(cities);
```



Example: map

```
var a = [1, 2, 3];

for(var i=0; i<a.length; i++){
    a[i] = a[i] * 2;
}

for(var i=0; i<a.length; i++){
    console.log(a[i]);
}
```

```
var a = [1, 2, 3];

function map(f, a){
    for(var i=0; i<a.length; i++){
        a[i] = f(a[i]);
    }
}

map(function(x){return x * 2;}, a);
map(alert, a);
```

Example: reduce

```
var nums = [1, 2, 3, 4];

function sum(a){
    var sum = 0;
    for(var i=0; i<a.length; i++)
        sum += a[i];
    return sum;
}

function mult(a){
    var mult=1;
    for(var i=0; i<a.length; i++)
        mult *= a[i];
    return mult;
}

console.log(sum(nums));
console.log(mult(nums));
```

```
var nums = [1, 2, 3, 4];

function reduce(f, a, init){
    var s = init;
    for(var i=0; i<a.length; i++)
        s = f(s, a[i]);
    return s;
}

function add(a, b){
    return a+b;
}
function mult(a, b){
    return a*b;
}

console.log(reduce(add, nums, 0));
console.log(reduce(mult, nums, 1));
```

Manipulating documents

- So far: HTML, CSS, JavaScript.
- But how can we use JavaScript to modify nodes from DOM?
- Answer: **document object**.
- When an HTML document is loaded by a browser, it becomes a **document object**, containing the root node of the HTML document.

Document object

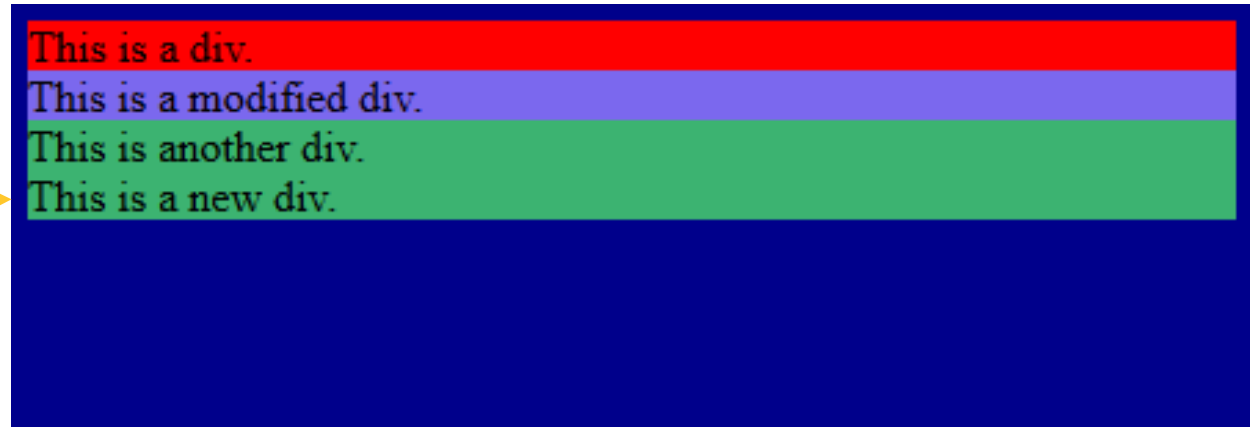
DOM elements using selectors

```
var allDivs = document.querySelector('div');
var myDiv = document.querySelector('#mydiv');
var mySecondDiv = document.querySelector('#myseconddiv');
var myClass = document.querySelector('.myclass');
```

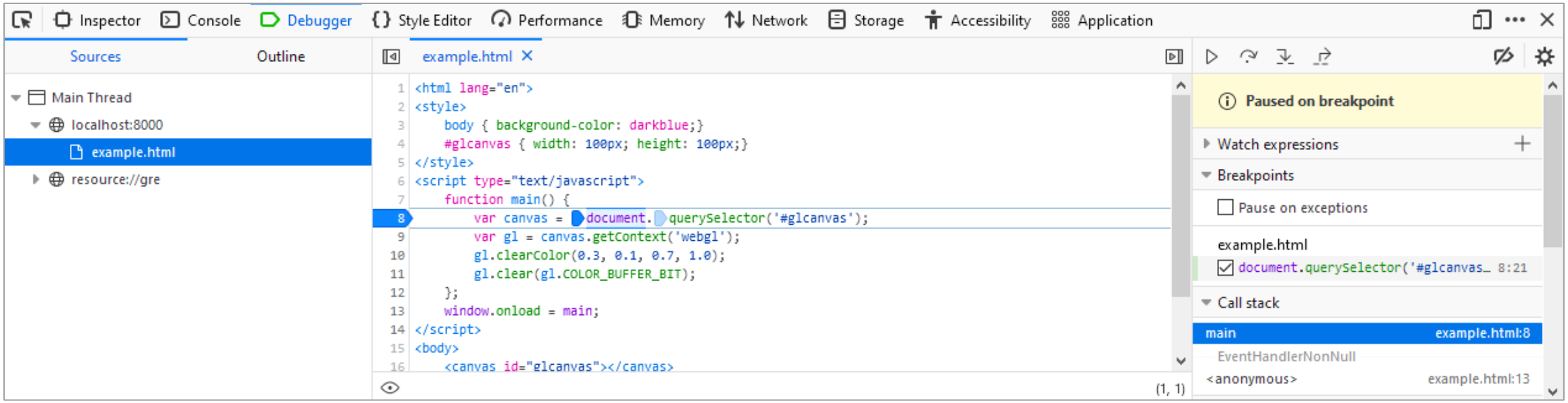
```
mySecondDiv.textContent = 'This is a modified div.';
```

DOM elements using selectors

```
var newDiv = document.createElement('div');
newDiv.textContent = 'This is a new div.';
newDiv.className = 'myclass';
document.querySelector('body').appendChild(newDiv);
```



Debugging JavaScript



Finally drawing something

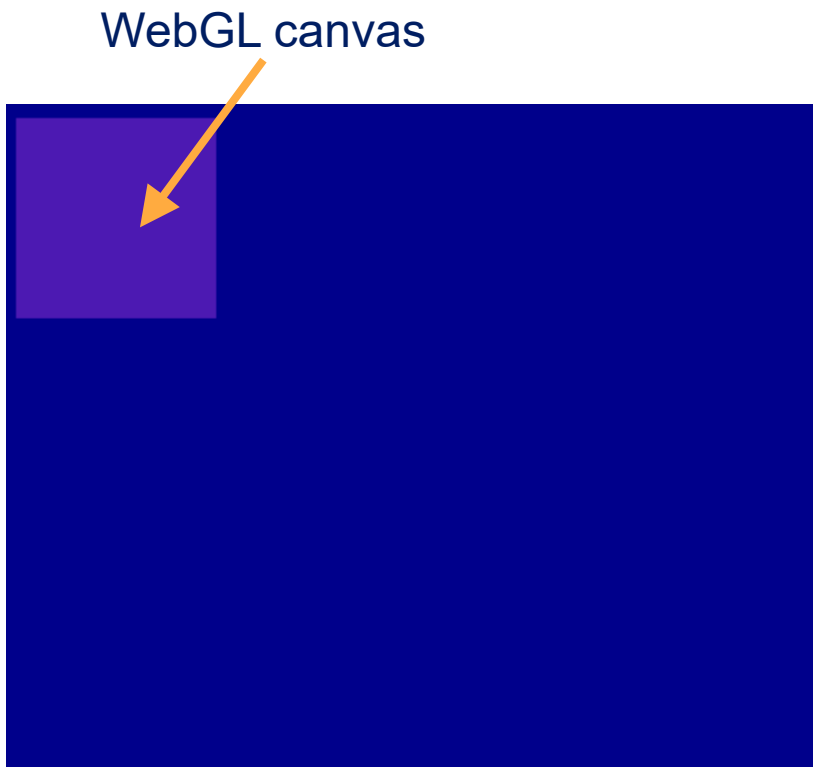
- Several ways to draw graphics on the web:
  - SVG
    - XML-based format for vector images.
    - Simple option for small data.
    - Easy event and CSS integration.
  - Canvas
    - HTML element.
    - No object-level interaction.
  - WebGL
    - Complex 3D geometries.
    - Uses rendering pipeline.
    - Hardware acceleration.

WebGL: a bird’s-eye view

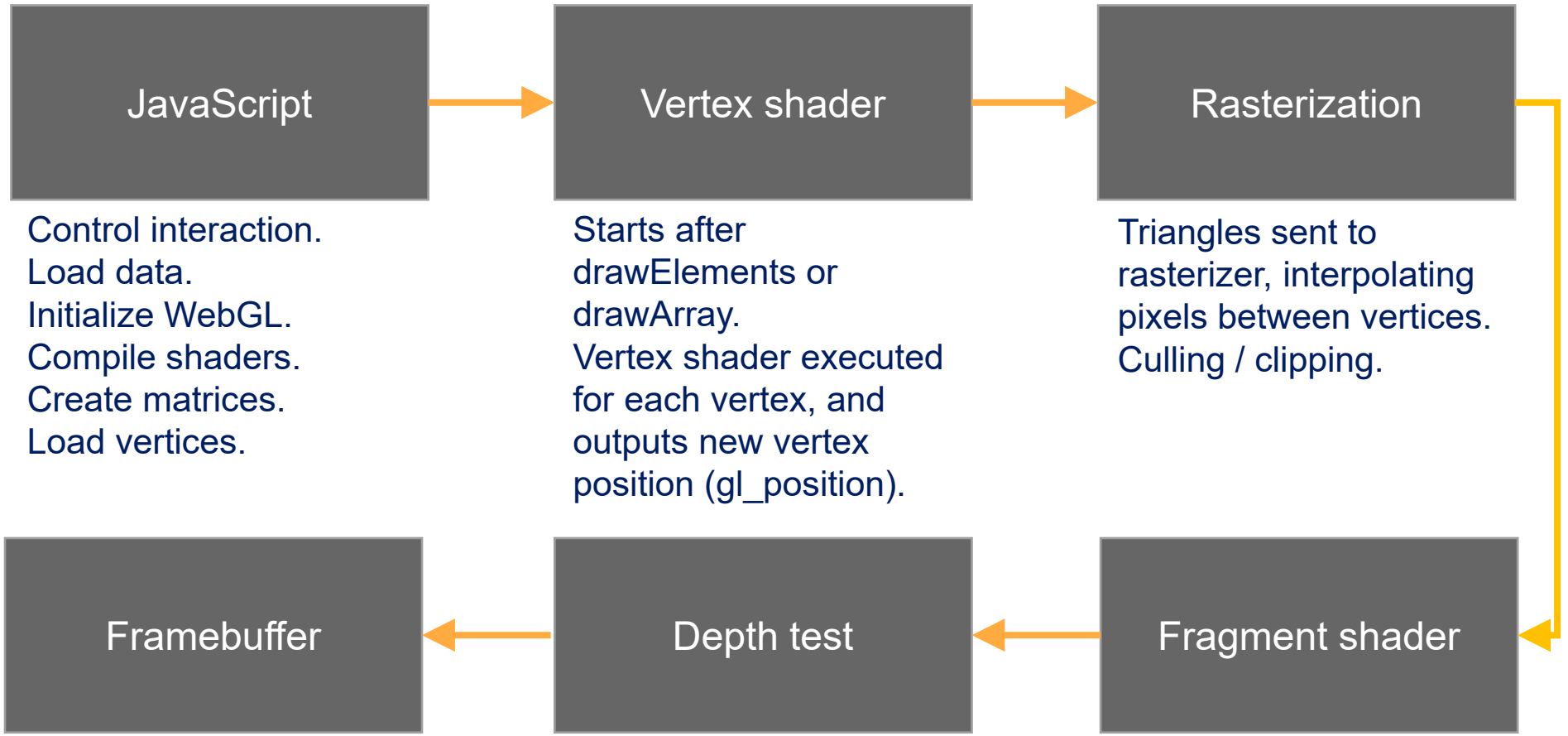
- API for rendering graphics within a web browser without plug-ins.
- Hardware accelerated.
- Shader based (no fixed-function API).
  - Fixed function pipeline: set of calls for matrix transformation, lighting.
  - Programmable pipeline: shaders for vertex and fragment processing.
- WebGL 2.0 based on OpenGL ES 3.0.

WebGL: a bird's-eye view

```
<html lang="en">
<style>
    body { background-color: darkblue;}
    #glcanvas { width: 100px; height: 100px;}
</style>
<script type="text/javascript">
    function main() {
        var canvas = document.querySelector('#glcanvas');
        var gl = canvas.getContext('webgl');
        gl.clearColor(0.3, 0.1, 0.7, 1.0);
        gl.clear(gl.COLOR_BUFFER_BIT);
    };
    window.onload = main;
</script>
<body>
    <canvas id="glcanvas"></canvas>
</body>
</html>
```



WebGL: a bird's eye view



Control interaction.
Load data.
Initialize WebGL.
Compile shaders.
Create matrices.
Load vertices.

Starts after drawElements or drawArray.
Vertex shader executed for each vertex, and outputs new vertex position (gl_position).

Triangles sent to rasterizer, interpolating pixels between vertices.
Culling / clipping.

The final image.

Executed for each fragmented outputted by rasterization.

Lab

- Web server:
  - Python: https://mzl.la/3bSLff0
- Development:
  - Visual Studio Code: https://code.visualstudio.com/
  - Atom: https://atom.io/
  - Sublime: https://www.sublimetext.com/
- Double check if your browser supports WebGL: https://get.webgl.org/