Javascript

Because ECMAScript sounds horrible

Javascript

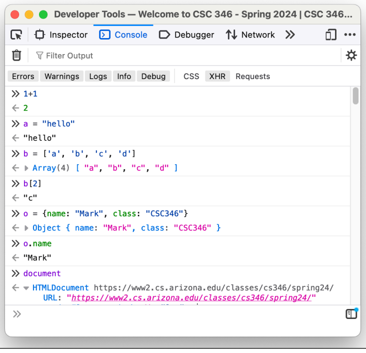
Javascript is a general purpose programming language

- It usually runs within a browser
  - Node.js runs Javascript in a server / application context
- Developed in the mid nineties as a simple way to provide interactivity to web pages.
- Originally developed by Brendan Eich working at Netscape
- Submitted to ECMA standards body in 1996
- ECMAScript 5.1 released in 2011

Javascript In A Browser

- REPL
  - Read-Eval-Print Loop
- All major browsers have a Javascript REPL system in the console

Javascript In A Browser



```
>> 1+1
<- 2
>> a = "hello"
<- "hello"
>> b = ['a', 'b', 'c', 'd']
<- ▸ Array(4) [ "a", "b", "c", "d" ]
>> b[2]
<- "c"
>> o = {name: "Mark", class: "CSC346"}
<- ▸ Object { name: "Mark", class: "CSC346" }
>> o.name
<- "Mark"
>> document
<- ▾ HTMLDocument https://www2.cs.arizona.edu/classes/cs346/spring24/
     URL: "https://www2.cs.arizona.edu/classes/cs346/spring24/"
```

Documentation

http://ecma262-5.com/ELS5_HTML.htm

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference

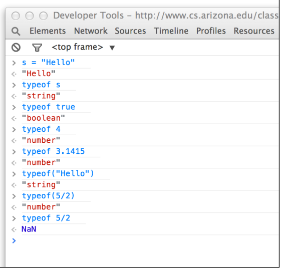
Data Types

Basic Data Types

- number
- boolean
- string
- function
- object

Data Types
`typeof`

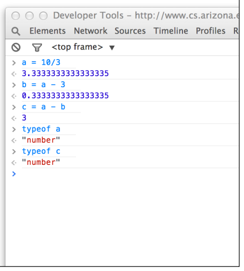
- `typeof` unary operator
- lets us know what we’re dealing with
- If you’re evaluating a complex operation, you need parenthesis. Not because `typeof` is a function, but to make sure that there’s only one argument to `typeof`


Developer Tools – http://www.cs.arizona.edu/class
Elements Network Sources Timeline Profiles Resources
<top frame>

```
> s = "Hello"
< "Hello"
> typeof s
< "string"
> typeof true
< "boolean"
> typeof 4
< "number"
> typeof 3.1415
< "number"
> typeof("Hello")
< "string"
> typeof(5/2)
< "number"
> typeof 5/2
< NaN
>
```

Numbers

- Javascript has a single number datatype to deal with all numbers.
- No distinction between integers, floats, doubles, etc.
- All numbers are represented as floating point numbers, but if the fractional part is zero, they’re shown as integers.


Developer Tools – http://www.cs.arizona.e
Elements Network Sources Timeline Profiles R
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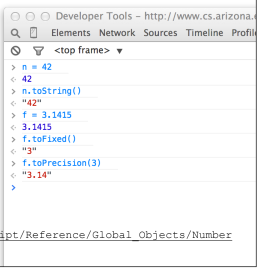
```
> a = 10/3
< 3.3333333333333335
> b = a - 3
< 0.3333333333333335
> c = a - b
< 3
> typeof a
< "number"
> typeof c
< "number"
>
```

Numbers

- Numbers stored in variables are converted objects when needed, to have methods and properties
- Number.toString()
- Number.toPrecision()

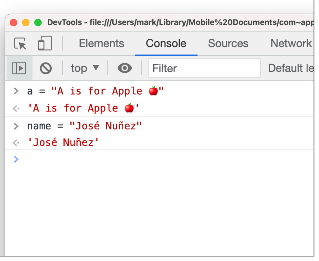

Developer Tools – http://www.cs.arizona.e
Elements Network Sources Timeline Profile
<top frame>

```
> n = 42
< 42
> n.toString()
< "42"
> f = 3.1415
< 3.1415
> f.toFixed()
< "3"
> f.toPrecision(3)
< "3.14"
>
```

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Number

Strings

- A series of zero or more characters.
- Unicode support is pretty good.


DevTools - file:///Users/mark/Library/Mobile%20Documents/com~app
Elements
Console
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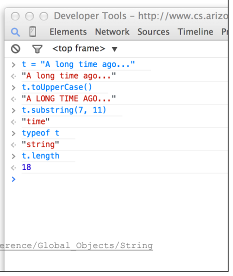
```
> a = "A is for Apple 🍎"
<· 'A is for Apple 🍎'
> name = "José Nuñez"
<· 'José Nuñez'
>
```

Strings

- String variables are also converted to objects as needed.
- `String.toUpperCase()`
- `String.substring(start, end)`
- Note the difference between `.substring()` and `.length`
  - One is a method, one is a property

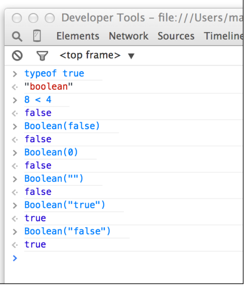


```
> t = "A long time ago..."
<· "A long time ago..."
> t.toUpperCase()
<· "A LONG TIME AGO..."
> t.substring(7, 11)
<· "time"
> typeof t
<· "string"
> t.length
<· 18
>
```

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/String

Boolean

- Boolean for `true` and `false`.
- Comparisons
- Coerce other datatypes into Boolean.
- Note the behavior of the Boolean value for strings.
  - Empty string is `false`
  - Other strings are `true`. Even “false”!



```
> typeof true
<· "boolean"
> 8 < 4
<· false
> Boolean(false)
<· false
> Boolean(0)
<· false
> Boolean("")
<· false
> Boolean("true")
<· true
> Boolean("false")
<· true
>
```

Variables

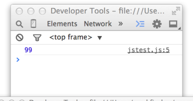
- Variable names can be any combination of letters, numbers, an underscore (_), or $
- Variable names cannot start with a number.
- Variables do not need to be declared.
- The `var` keyword can be used to declare and scope variables.

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Statements/var

Variables

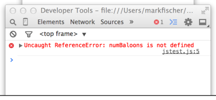
- Variables have global scope unless `var` is used to declare a variable.

```
var foo = function() {
  numBaloons = 99;
}
foo();
console.log(numBaloons);
```



```
99                                   jstest.js:5
>
```

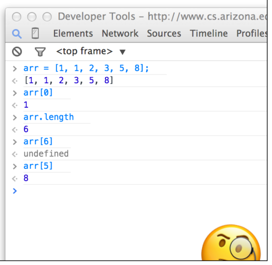
```
var foo = function() {
  var numBaloons = 99;
}
foo();
console.log(numBaloons);
```



```
▶Uncaught ReferenceError: numBaloons is not defined
                                     jstest.js:5
>
```

Arrays

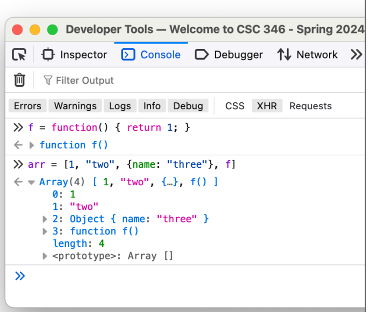
- Collection of values
- Created with `[n, n+1,…k-1]` syntax
- Array access with brackets: `n[ ]`
- Length property
- Standard Zero based indexing



```
> arr = [1, 1, 2, 3, 5, 8];
< [1, 1, 2, 3, 5, 8]
> arr[0]
< 1
> arr.length
< 6
> arr[6]
< undefined
> arr[5]
< 8
>
```

Arrays

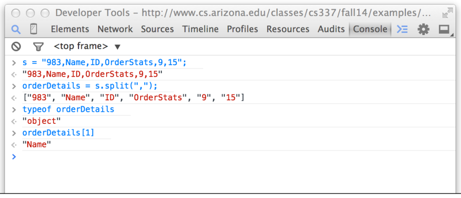
- Arrays can be collections of many different datatypes.



```
>> f = function() { return 1; }
<- ▸ function f()
>> arr = [1, "two", {name: "three"}, f]
<- ▾ Array(4) [ 1, "two", {…}, f() ]
      0: 1
      1: "two"
    ▸ 2: Object { name: "three" }
    ▸ 3: function f()
      length: 4
    ▸ <prototype>: Array []
>>
```

Arrays From Strings

- `String.split()` to create an array from a string.


Developer Tools – http://www.cs.arizona.edu/classes/cs337/fall14/examples/…
Elements
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Console
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```
> s = "983,Name,ID,OrderStats,9,15";
<· "983,Name,ID,OrderStats,9,15"
> orderDetails = s.split(",");
<· ["983", "Name", "ID", "OrderStats", "9", "15"]
> typeof orderDetails
<· "object"
> orderDetails[1]
<· "Name"
>
```

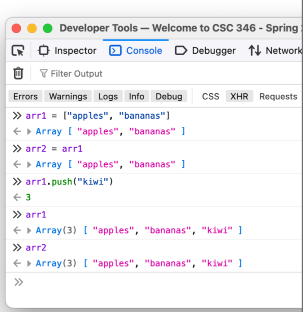
Array Methods

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Array

- Lots of useful array methods.
- `.contains(<some value>)` // returns true or false
- `.join(<glue string>)` // joins all elements together with glue and returns a string.
- `.toString()` // Quick string representation of the array
- `.pop()  .push()  .shift()  .unshift()` // Standard array methods
- `.sort()` // Sorts elements according to criteria
- `.splice()` // Adds or removes elements from an array

Array Assignment

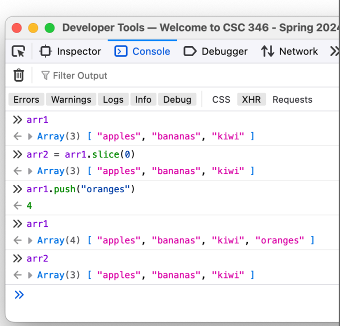
- Assigning an array to another variable assigns a reference of the array to the variable, not a copy.


Developer Tools — Welcome to CSC 346 - Spring

```
>> arr1 = ["apples", "bananas"]
<- ▸ Array [ "apples", "bananas" ]
>> arr2 = arr1
<- ▸ Array [ "apples", "bananas" ]
>> arr1.push("kiwi")
<- 3
>> arr1
<- ▸ Array(3) [ "apples", "bananas", "kiwi" ]
>> arr2
<- ▸ Array(3) [ "apples", "bananas", "kiwi" ]
>>
```

Array Assignment

- To make a copy of an array, use the `.slice(0)` method.

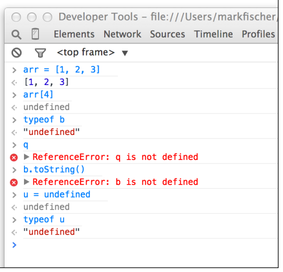

Developer Tools — Welcome to CSC 346 - Spring 2024

```
>> arr1
<- ▸ Array(3) [ "apples", "bananas", "kiwi" ]
>> arr2 = arr1.slice(0)
<- ▸ Array(3) [ "apples", "bananas", "kiwi" ]
>> arr1.push("oranges")
<- 4
>> arr1
<- ▸ Array(4) [ "apples", "bananas", "kiwi", "oranges" ]
>> arr2
<- ▸ Array(3) [ "apples", "bananas", "kiwi" ]
>>
```

undefined

developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/undefined

- Javascript has a special value for things that are not defined: `undefined`
- Out of bounds requests
- Un-initialized variables
- `undefined` is a property of the *global object*. Its type is undefined.


Developer Tools – file:///Users/markfischer/

```
> arr = [1, 2, 3]
< [1, 2, 3]
> arr[4]
< undefined
> typeof b
< "undefined"
> q
✖ ▶ ReferenceError: q is not defined
> b.toString()
✖ ▶ ReferenceError: b is not defined
> u = undefined
< undefined
> typeof u
< "undefined"
>
```

Objects

- Objects are very flexible data structures.
- A basic object:

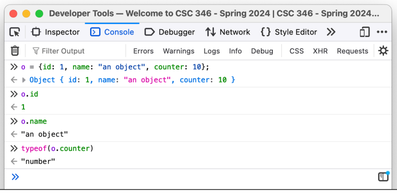
```
o = {id: 1, name: "an object", counter: 10};
```

- Create property names and values using `key: value` syntax.
- Separate multiple properties by commas.

Objects

- Access properties via dot syntax

```
o = {id: 1, name: "an object", counter: 10};
```

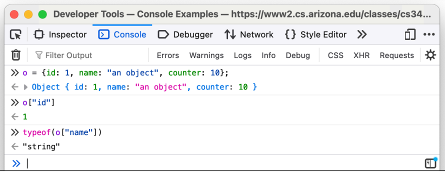


```
>> o = {id: 1, name: "an object", counter: 10};
← ▸ Object { id: 1, name: "an object", counter: 10 }
>> o.id
← 1
>> o.name
← "an object"
>> typeof(o.counter)
← "number"
>>
```

Objects

- Act as “Associative Arrays” or “Key / Value” arrays, or “Dictionary” array
- `arr["key"]` syntax

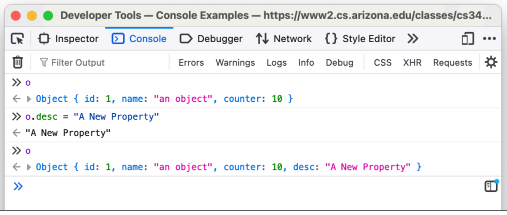
```
o = {id: 1, name: "an object", counter: 10};
```



```
>> o = {id: 1, name: "an object", counter: 10};
← ▸ Object { id: 1, name: "an object", counter: 10 }
>> o["id"]
← 1
>> typeof(o["name"])
← "string"
>> |
```

Objects

- Assigning to undefined properties creates them

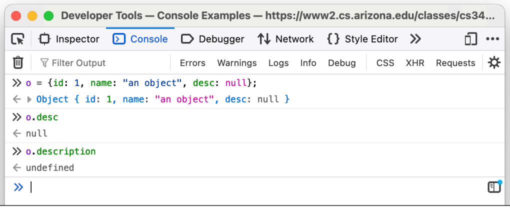


```
>> o
← ▸ Object { id: 1, name: "an object", counter: 10 }
>> o.desc = "A New Property"
← "A New Property"
>> o
← ▸ Object { id: 1, name: "an object", counter: 10, desc: "A New Property" }
>>
```

null

developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/null

- Null is a literal value representing an "empty" or non-existent value.



```
>> o = {id: 1, name: "an object", desc: null};
← ▸ Object { id: 1, name: "an object", desc: null }
>> o.desc
← null
>> o.description
← undefined
>> |
```

Operators

- Arithmetic Operators: `+ - / * % ++ --`
- String concatenation: `+`
- Logical Operators: `&& || !`
- Comparisons: `<  >  <=  >=`
- Ternary Operator: `condition ? true expr : false expr`
- Bitwise Operators: `<<  >>  ^  ~`

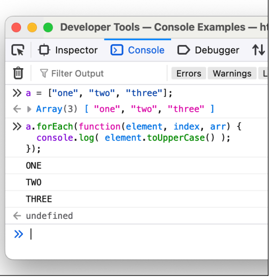
Control Structures

- `if (condition) { stmt1 } else { stmt2 }`
- `while (condition) { statements }`
- `for (i = 0; i < 10; i++) { statements }`
- Pretty much work like every other C or Java style language

Control Structures: forEach

- Arrays have a special `forEach` method for performing some action relating to each element of the array
- The `forEach` method takes a *function* as an argument.

```
a = ["one", "two", "three"];
a.forEach(function(element, index, arr) {
  console.log( element.toUpperCase() );
});
```



```
>> a = ["one", "two", "three"];
← ▸ Array(3) [ "one", "two", "three" ]
>> a.forEach(function(element, index, arr) {
     console.log( element.toUpperCase() );
   });
   ONE
   TWO
   THREE
← undefined
>> |
```

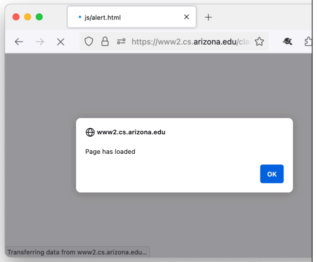
Basic I/O

- Alerts
- Log to Console
- Confirms
- Prompt
- DOM Manipulation
- Debugger
- No Direct Local File I/O!

alert( )

- Display a modal dialog box with the specified text.
- Pauses execution of Javascript until dialog is dismissed.

```
alert("Hello World");
```

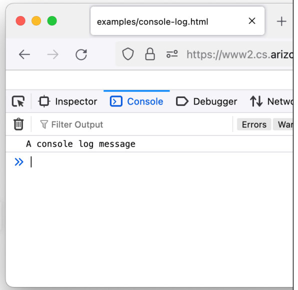

js/alert.html
https://www2.cs.arizona.edu/
www2.cs.arizona.edu
OK
Transferring data from www2.cs.arizona.edu…

Page has loaded

console.log( )

- Quick way to get some debugging out.
- Doesn't block execution, so usually a better choice for debugging and testing than `alert()`.

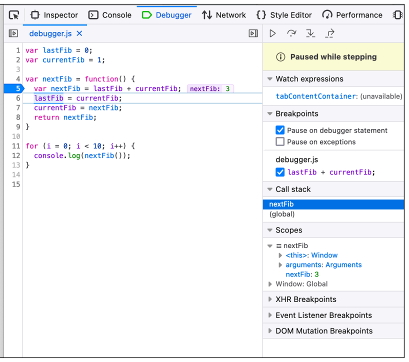
```
console.log("A console log message");
```



```
A console log message
```

Debugger

- Most browsers have a full featured interactive debugger built in.
- Breakpoints, watched expressions, step through execution, etc.
- Example.



```
var lastFib = 0;
var currentFib = 1;

var nextFib = function() {
  var nextFib = lastFib + currentFib;  nextFib: 3
  lastFib = currentFib;
  currentFib = nextFib;
  return nextFib;
}

for (i = 0; i < 10; i++) {
  console.log(nextFib());
}
```

tabContentContainer: (unavailable)

[✓] Pause on debugger statement
[ ] Pause on exceptions

debugger.js
[✓] lastFib + currentFib;

nextFib
(global)

nextFib
<this>: Window
arguments: Arguments
nextFib: 3
Window: Global

Functions

- Multiple ways to define a function

```
function echo(a) {
  return a;
}

echoTwo = function(a) {
  return a;
}

var echoThree = function(a) {
  return a;
}

console.log( echo("one") );
console.log( echoTwo("two") );
console.log( echoThree("three") );
```

Functions

Declares a named function without requiring assignment

Declares a *global* variable `echoTwo` and assigns an anonymous function to it

Declares a *local* variable `echoThree` and assigns an anonymous function to it

```
function echo(a) {
  return a;
}

echoTwo = function(a) {
  return a;
}

var echoThree = function(a) {
  return a;
}

console.log( echo("one") );
console.log( echoTwo("two") );
console.log( echoThree("three") );
```

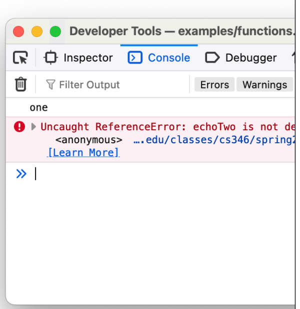
Functions

- Does any of this matter?
- What if we call the functions before they're declared?

```
console.log( echo("one") );
console.log( echoTwo("two") );
console.log( echoThree("three") );

function echo(a) {
  return a;
}

echoTwo = function(a) {
  return a;
}

var echoThree = function(a) {
  return a;
}
```

Functions

```
console.log( echo("one") );
console.log( echoTwo("two") );
console.log( echoThree("three") );

function echo(a) {
  return a;
}

echoTwo = function(a) {
  return a;
}

var echoThree = function(a) {
  return a;
}
```



```
one
Uncaught ReferenceError: echoTwo is not de
  <anonymous>  ….edu/classes/cs346/spring2
 [Learn More]
»
```

Functions

- The first style has a symbol table entry created for it at parse time. So it can be referenced immediately during runtime.
- The other two have symbol table entries created at runtime, so aren't available until after they've been executed.

```
console.log( echo("one") );
console.log( echoTwo("two") );
console.log( echoThree("three")

function echo(a) {
  return a;
}

echoTwo = function(a) {
  return a;
}

var echoThree = function(a) {
  return a;
}
```

javascriptweblog.wordpress.com/2010/07/06/function-declarations-vs-function-expressions/

Functions

- So should we always use Function Declarations?
  - Well, it depends…

```
//Function Declaration
function add(a,b) {return a + b};
//Function Expression
var add = function(a,b) {return a + b};
```

Functions

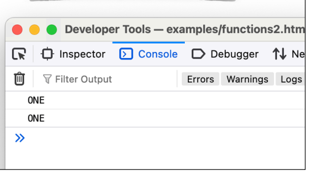
- What if we want to re-define a function somewhere in the code?
- What is the console output here?

```
function echo(a) {
  return a;
}

console.log( echo("one") );


function echo(a) {
  return a.toUpperCase();
}

console.log( echo("one") );
```

Functions

```
function echo(a) {
  return a;
}

console.log( echo("one") );


function echo(a) {
  return a.toUpperCase();
}

console.log( echo("one") );
```

- Hmm, maybe not what we were expecting.
- Function Declarations are ‘hoisted’ to the top at parse time, so when executed, the last declared version wins.



```
ONE
ONE
```

Function Declarations

- Can only appear as block level elements.
- Are ‘hoisted’ to the top at parse time, before run time.
- Cannot be nested within non-function blocks.
- Are scoped by where they are declared, like `var`

Function Expressions

- Can be used anywhere an expression is valid.
  - Can be more flexible because of this.
- Are evaluated and assigned at run time.

Function Expressions

- Recall that functions are first-class data types in JavaScript. This means that anywhere in the language you can use an expression, you can substitute a function.

```
function logWithFormat(message, formatter) {
  let formattedMessage = formatter(message)
  console.log(formattedMessage)
}

logWithFormat(“Hello”, function(s) { return s.toUpperCase() })
// prints “HELLO” to the console
```

Arrow Functions

- Many of these “callback” style functions require the same format.
- Of course programmers developed a shorter way to write them

```
logWithFormat(“Hello”, function(s) { return s.toUpperCase() })

logWithFormat(“Hello”,(s) => s.toUpperCase())
```

Arrow Functions

- Arrow functions are anonymous. There's no named symbol to reference anywhere else
- If the function body is simple, you can omit the `{ }` and the statement will automatically be returned
- If your function body is more complex, you must explicitly return a value
- Arrow functions have other benefits

```
(s) => s.toUpperCase()

(s) => {
   s2 doWork(s)
   return s2.toUpperCase()
}
```

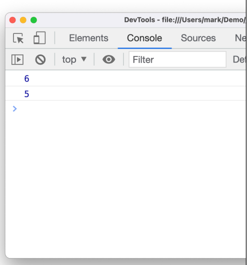
https://developer.mozilla.org/en-US/docs/Web/JavaScript/Guide/Functions#arrow_functions

Objects and Functions

- Functions can be added to objects as property variables.
- Object "methods" are really properties with functions assigned to them.

Objects and Functions

```
var doubleMe = function(x) {
  return 2 * x;
}

var halveMe = function(x) {
  return x/2;
}

var myLib = {
  version: 0.3,
  name: "My Test Library",
  double: doubleMe,
  half: halveMe
}

console.log( myLib.double(3) );
console.log( myLib.half(10) );
```



```
6
5
>
```

Objects and Functions

- Using anonymous function expressions instead.
- Arrow functions are especially popular in this situation.

```
var myLib = {
  version: 0.4,
  name: "My Test Library",
  double: function(x) { return 2 * x; },
  half: function(x) { return x/2; }
}

console.log( myLib.double(3) );
console.log( myLib.half(10) );
```

```
var myLib = {
  version: 0.4,
  name: "My Test Library",
  double: (x) => 2 * x,
  half: (x) => x/2
}

console.log( myLib.double(3) );
console.log( myLib.half(10) );
```

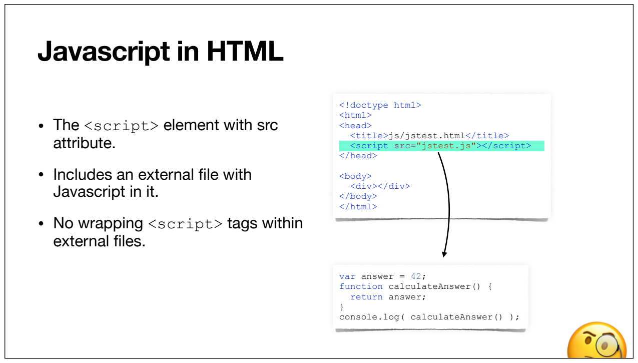
Javascript in HTML

- Where does our Javascript live?
- Inline in an HTML document inside a `<script>` element
- Included in an external file via a `<script>` element.

Javascript in HTML

- The `<script>` element with inline content
- Within the `<script>` element, we're parsing Javascript, not HTML

```
<!doctype html>
<head>
  <title>js/jstest.html</title>

  <script>
    var answer = 42;
    function calculateAnswer() {
      return answer;
    }
    console.log( calculateAnswer() );
  </script>
</head>

<body>
  <div></div>
  <div></div>
</body>
</html>
```

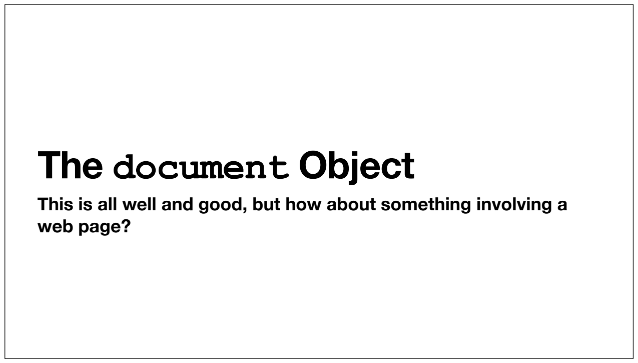


Javascript in HTML

- The `<script>` element with src attribute.
- Includes an external file with Javascript in it.
- No wrapping `<script>` tags within external files.

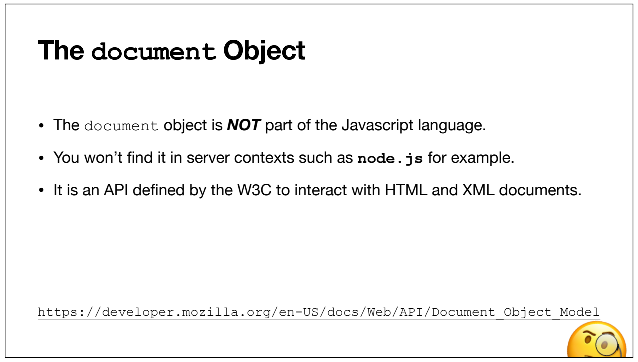
```html
<!doctype html>
<html>
<head>
  <title>js/jstest.html</title>
  <script src="jstest.js"></script>
</head>

<body>
  <div></div>
</body>
</html>
```

```javascript
var answer = 42;
function calculateAnswer() {
  return answer;
}
console.log( calculateAnswer() );
```



The `document` Object

This is all well and good, but how about something involving a web page?



The `document` Object

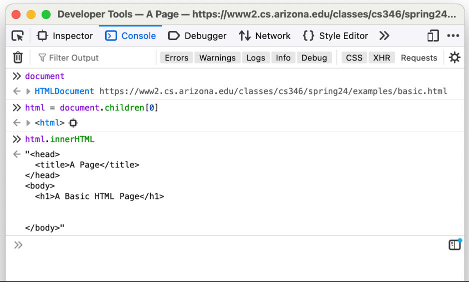
- The `document` object is ***NOT*** part of the Javascript language.
- You won't find it in server contexts such as **`node.js`** for example.
- It is an API defined by the W3C to interact with HTML and XML documents.

https://developer.mozilla.org/en-US/docs/Web/API/Document_Object_Model

The `document` Object

- Browsers parse the HTML and CSS of a page, and build an object model in memory.
- The browser exposes this object to us for use with our Javascript as the `document` object.

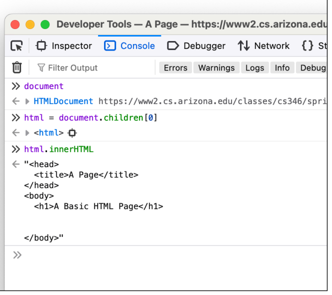
The `document` Object



```
>> document
← ▸ HTMLDocument https://www2.cs.arizona.edu/classes/cs346/spring24/examples/basic.html
>> html = document.children[0]
← ▸ <html>
>> html.innerHTML
← "<head>
    <title>A Page</title>
  </head>
  <body>
    <h1>A Basic HTML Page</h1>


  </body>"
>>
```

The `document` Object

- `document` elements are *objects*, so accessing their properties is done with the dot syntax
- `object.property`
- `html.innerHTML` for example



```
>> document
← ▸ HTMLDocument https://www2.cs.arizona.edu/classes/cs346/spri
>> html = document.children[0]
← ▸ <html>
>> html.innerHTML
← "<head>
    <title>A Page</title>
  </head>
  <body>
    <h1>A Basic HTML Page</h1>


  </body>"
>>
```

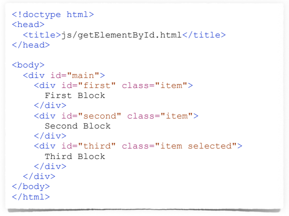
DOM Selection

- Starting with the `document` root and drilling down via `.children` is tedious. Can we get at elements some other way?
- `document.getElementById(“main”)`
- `document.getElementsByTagName(“p”)`
- `document.getElementsByClassName(“error”)`

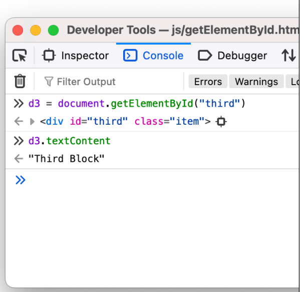
getElementById

- Gets an HTMLElement object from the document based on an ID.
- Since ID must be unique, this method returns a single element, not an array of elements.

getElementById



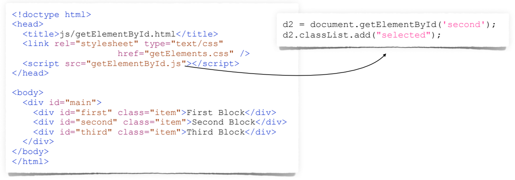
```
<!doctype html>
<head>
  <title>js/getElementById.html</title>
</head>

<body>
  <div id="main">
    <div id="first" class="item">
      First Block
    </div>
    <div id="second" class="item">
      Second Block
    </div>
    <div id="third" class="item selected">
      Third Block
    </div>
  </div>
</body>
</html>
```



```
>> d3 = document.getElementById("third")
← ▸ <div id="third" class="item">
>> d3.textContent
← "Third Block"
>>
```

Updating the DOM

- Now that we can get an element, can we do something with it?

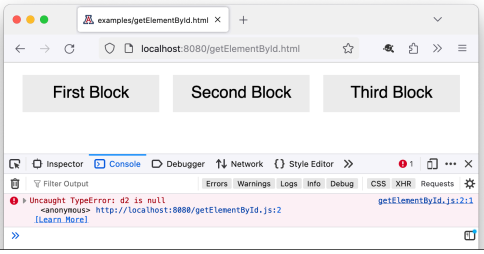


```html
<!doctype html>
<head>
  <title>js/getElementById.html</title>
  <link rel="stylesheet" type="text/css"
                    href="getElements.css" />
  <script src="getElementById.js"></script>
</head>

<body>
  <div id="main">
    <div id="first" class="item">First Block</div>
    <div id="second" class="item">Second Block</div>
    <div id="third" class="item">Third Block</div>
  </div>
</body>
</html>
```

```javascript
d2 = document.getElementById('second');
d2.classList.add("selected");
```

Updating the DOM

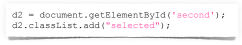
- Hmm nothing happened. Why? Check the console.



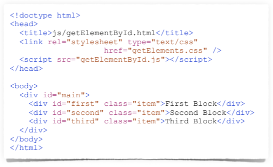
```
Uncaught TypeError: d2 is null                              getElementById.js:2:1
    <anonymous> http://localhost:8080/getElementById.js:2
   [Learn More]
```

Updating the DOM

- Uncaught TypeError: Cannot read properties of null?? But how can d2 be null?



```javascript
d2 = document.getElementById('second');
d2.classList.add("selected");
```



```html
<!doctype html>
<head>
  <title>js/getElementById.html</title>
  <link rel="stylesheet" type="text/css"
                    href="getElements.css" />
  <script src="getElementById.js"></script>
</head>

<body>
  <div id="main">
    <div id="first" class="item">First Block</div>
    <div id="second" class="item">Second Block</div>
    <div id="third" class="item">Third Block</div>
  </div>
</body>
</html>
```

Waiting for the DOM to load

- The browser waits for no DOM
- The browser parses the file, loads the `getElementById.js` file, and executes it all before the rest of the HTML is parsed and the DOM is created.

```html
<!doctype html>
<head>
  <title>js/getElementById.html</title>
  <link rel="stylesheet" type="text/css"
                    href="getElements.css" />
  <script src="getElementById.js"></script>
</head>

<body>
  <div id="main">
    <div id="first" class="item">First Block</div>
    <div id="second" class="item">Second Block</div>
    <div id="third" class="item">Third Block</div>
  </div>
</body>
</html>
```

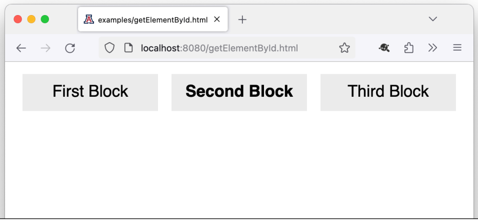
Waiting for the DOM to load

- What if we just move the `<script>` element down to the bottom?

```html
<!doctype html>
<head>
  <title>js/getElementById.html</title>
  <link rel="stylesheet" type="text/css"
                    href="getElements.css" />
</head>

<body>
  <div id="main">
    <div id="first" class="item">First Block</div>
    <div id="second" class="item">Second Block</div>
    <div id="third" class="item">Third Block</div>
  </div>

  <script src="getElementById.js"></script>
</body>
</html>
```

Waiting for the DOM to load

- Works!


examples/getElementById.html
localhost:8080/getElementById.html
First Block
Second Block
Third Block

Waiting for the DOM to load

- That seems… hackish. Isn't there a "right" way to do this?
- Well, its perfectly valid. `<script>` elements do not have to go in the `<head>`, although they frequently do.
- However, `<script>` elements that aren't in the `<head>` tend to get overlooked later, so we try to put them there if we can.

Events

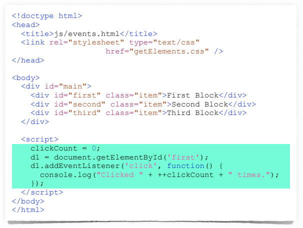
- The web browser is an Event Driven application.
- Documents load, links are clicked, HTTP requests are made and completed.
- Each of these is an event, and we can register event listeners (functions) which will be called as these events occur.
- These are called *callbacks.*

Events

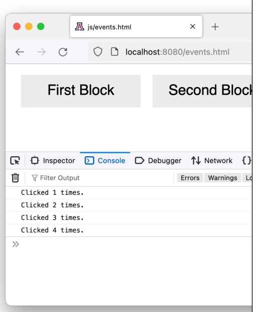
- *object*`.addEventListener('event', callback);`
- The object can be any object that responds to event listeners, such as an Element, the Document, or maybe the Window.

Events

- A basic example of a ‘click’ event handler.



```html
<!doctype html>
<head>
  <title>js/events.html</title>
  <link rel="stylesheet" type="text/css"
                  href="getElements.css" />
</head>

<body>
  <div id="main">
    <div id="first" class="item">First Block</div>
    <div id="second" class="item">Second Block</div>
    <div id="third" class="item">Third Block</div>
  </div>

  <script>
    clickCount = 0;
    d1 = document.getElementById('first');
    d1.addEventListener('click', function() {
      console.log("Clicked " + ++clickCount + " times.");
    });
  </script>
</body>
</html>
```

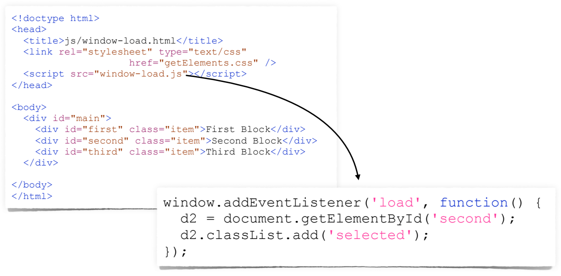


```
Clicked 1 times.
Clicked 2 times.
Clicked 3 times.
Clicked 4 times.
```

`window load` Event

- There’s also a `window` object that the DOM API provides for us.
- The Window object supports the `load` event, and we can register our own callback with this.
- The `load` event fires once the DOM has completed loading.

`window load` Event

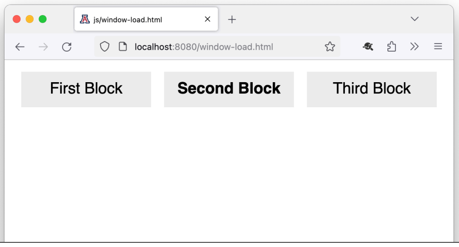


```html
<!doctype html>
<head>
  <title>js/window-load.html</title>
  <link rel="stylesheet" type="text/css"
                  href="getElements.css" />
  <script src="window-load.js"></script>
</head>

<body>
  <div id="main">
    <div id="first" class="item">First Block</div>
    <div id="second" class="item">Second Block</div>
    <div id="third" class="item">Third Block</div>
  </div>

</body>
</html>
```

```javascript
window.addEventListener('load', function() {
  d2 = document.getElementById('second');
  d2.classList.add('selected');
});
```

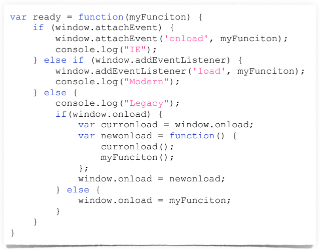
`window load` Event

- Works!



`window load` Event

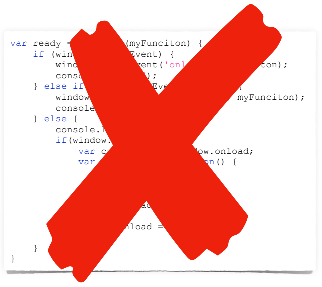
- IE 8 supported a different method, the *object*.`attachEvent` method.
- Even older browsers only support a single “onload” property.



```
var ready = function(myFunciton) {
    if (window.attachEvent) {
        window.attachEvent('onload', myFunciton);
        console.log("IE");
    } else if (window.addEventListener) {
        window.addEventListener('load', myFunciton);
        console.log("Modern");
    } else {
        console.log("Legacy");
        if(window.onload) {
            var curronload = window.onload;
            var newonload = function() {
                curronload();
                myFunciton();
            };
            window.onload = newonload;
        } else {
            window.onload = myFunciton;
        }
    }
}
```

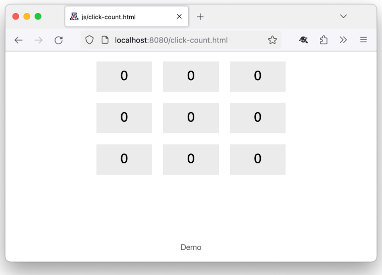
`window load` Event

- IE 8 supported a different method, the *object*.`attachEvent` method.
- Even older browsers only support a single “onload” property.
- But none of this matters anymore because we live in the future! 🎉



```
var ready = ~~function(myFunciton) {~~
    ~~if (window.attachEvent) {~~
        ~~window.attachEvent('onload', myFunciton);~~
        ~~console.log("IE");~~
    ~~} else if (window.addEventListener) {~~
        ~~window.addEventListener('load', myFunciton);~~
        ~~console.log("Modern");~~
    ~~} else {~~
        ~~console.log("Legacy");~~
        ~~if(window.onload) {~~
            ~~var curronload = window.onload;~~
            ~~var newonload = function() {~~
            ...
            ~~window.onload~~
        ...
    }
}
```

Putting Pieces Together



click-count.html

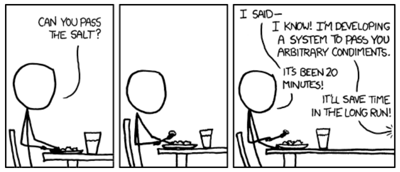
```html
<!doctype html>
<head>
  <title>js/click-count.html</title>
  <link rel="stylesheet" type="text/css"
                    href="click-count.css"/>
  <script src="click-count.js"></script>
</head>

<body>
  <div id="main">
  </div>
</body>
</html>
```

click-count.js

```javascript
var addCount = function(event) {
  var curCount = Number(this.textContent);
  curCount++;
  this.textContent = curCount.toString();
}

window.addEventListener('load', function() {
  var numBoxes = 9;
  main = document.getElementById('main');
  for (i = 0; i < numBoxes; i++) {
    var newBox = document.createElement("div");
    newBox.textContent = "0";
    newBox.addEventListener('click', addCount);
    main.appendChild(newBox);
  }
});
```

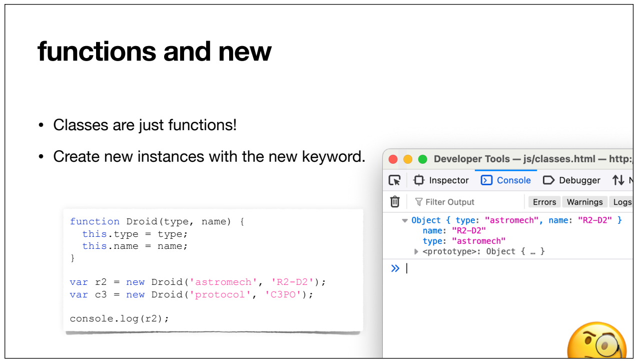
Classes

Javascript kind of has classes now?


CAN YOU PASS THE SALT?
I SAID—
I KNOW! I'M DEVELOPING A SYSTEM TO PASS YOU ARBITRARY CONDIMENTS.
IT'S BEEN 20 MINUTES!
IT'LL SAVE TIME IN THE LONG RUN!

Class Like Thingies

- Up until recently, Javascript has no “Class” concept.
- Objects are based on building on a prototype.
- “Instances” are not tied to a particular static Class definition.
- functions?



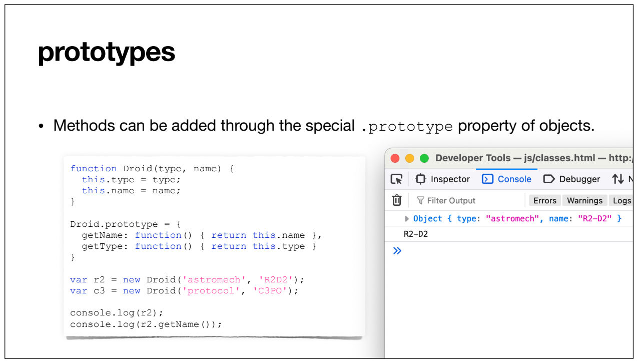
functions and new

- Classes are just functions!
- Create new instances with the new keyword.

```
function Droid(type, name) {
  this.type = type;
  this.name = name;
}

var r2 = new Droid('astromech', 'R2-D2');
var c3 = new Droid('protocol', 'C3PO');

console.log(r2);
```

Developer Tools — js/classes.html — http:

```
▼ Object { type: "astromech", name: "R2-D2" }
    name: "R2-D2"
    type: "astromech"
  ▶ <prototype>: Object { … }
»
```



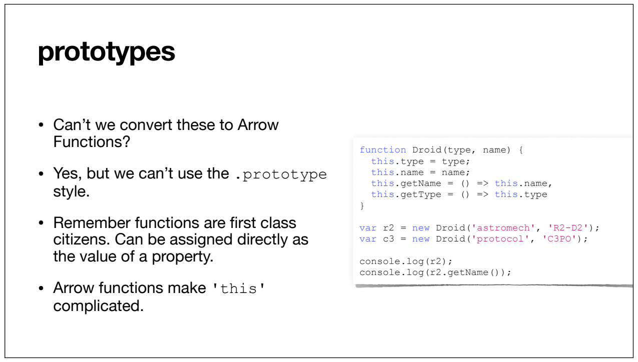
prototypes

- Methods can be added through the special `.prototype` property of objects.

```
function Droid(type, name) {
  this.type = type;
  this.name = name;
}

Droid.prototype = {
  getName: function() { return this.name },
  getType: function() { return this.type }
}

var r2 = new Droid('astromech', 'R2D2');
var c3 = new Droid('protocol', 'C3PO');

console.log(r2);
console.log(r2.getName());
```

Developer Tools — js/classes.html — http:

```
▶ Object { type: "astromech", name: "R2-D2" }
R2-D2
»
```



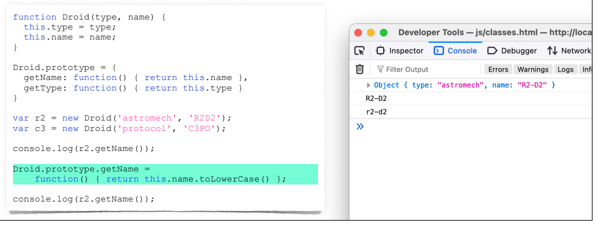
prototypes

- Can't we convert these to Arrow Functions?
- Yes, but we can't use the `.prototype` style.
- Remember functions are first class citizens. Can be assigned directly as the value of a property.
- Arrow functions make `'this'` complicated.

```
function Droid(type, name) {
  this.type = type;
  this.name = name;
  this.getName = () => this.name,
  this.getType = () => this.type
}

var r2 = new Droid('astromech', 'R2-D2');
var c3 = new Droid('protocol', 'C3PO');

console.log(r2);
console.log(r2.getName());
```

prototypes

- Don’t like the behavior of something? Re-define it on the fly

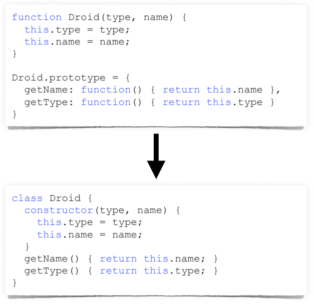


```
function Droid(type, name) {
  this.type = type;
  this.name = name;
}

Droid.prototype = {
  getName: function() { return this.name },
  getType: function() { return this.type }
}

var r2 = new Droid('astromech', 'R2D2');
var c3 = new Droid('protocol', 'C3PO');

console.log(r2.getName());

Droid.prototype.getName =
    function() { return this.name.toLowerCase() };

console.log(r2.getName());
```

```
▸ Object { type: "astromech", name: "R2-D2" }
R2-D2
r2-d2
»
```

ES2015 Classes

- Around 2015 Javascript added some extra syntax to make class definitions a little more straight forward.
- This is mostly accomplished with preprocessor manipulation. Under the hood it is still functions and prototypes.



```
function Droid(type, name) {
  this.type = type;
  this.name = name;
}

Droid.prototype = {
  getName: function() { return this.name },
  getType: function() { return this.type }
}
```

```
class Droid {
  constructor(type, name) {
    this.type = type;
    this.name = name;
  }
  getName() { return this.name; }
  getType() { return this.type; }
}
```

Asynchronous JavaScript

The JavaScript Event Loop

- The JavaScript Event Loop allows for asynchronous operation
- Required for the event driven architecture
- Browser can still process events like scrolling and mouse clicks while it waits for an external network call to complete
- Two main ways to deal with events that happen over time, typically I/O operations
  - Callbacks
  - Promises

Asynchronous JavaScript
Callbacks

- Register a callback function to be executed when an event occurs.

```
window.addEventListener('load', function() {
  console.log(“Page has loaded”)
});
```

```
window.addEventListener('load', () =>
  console.log(“Page has loaded”)
);
```

Asynchronous JavaScript
Callbacks

- Register a callback function to be executed when an event occurs.
- JavaScript stores the anonymous function on the stack, and links it to the load event. When the window finishes loading, the JavaScript engine calls all registered callback functions for that event.

```
() => console.log("Page has loaded")
```

Asynchronous JavaScript
Callbacks

- This model works well for simple workflows, but has problems when you need to perform multiple asynchronous tasks in a specific order.
- This quickly becomes cumbersome and has come to be known as “callback hell” or “the dreaded callback pyramid”

```
window.addEventListener('load', function() {
  callExternalAPI(apiURL, function(response) {
    console.log(response.json())
  })
});
```

Asynchronous JavaScript
Promises

- Promises arose to combat this model, and fix many of its shortcomings
- A Promise object wraps an asynchronous operation to manage its eventual completion or failure
- Essentially, a promise is a returned object to which you attach callbacks, instead of passing callbacks into a function.

```
callExternalAPI(apiURL)
  .then((result) => callAnotherAPI(api2URL, result))
  .then((response) => console.log(response.json())
```

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Guide/Using_promises

Asynchronous JavaScript
Promises

- Newer APIs such as the `fetch` API, support Promises by default, but many older ones don't. For example the `window.addEventListener` method.
- Can wrap these functions in a new Promise object
- Useful for combining new Promise code with older APIs

```
const windowEvent = (e) =>
   new Promise((resolve) => window.addEventListener(e, resolve))

windowEvent('load')
  .then(() => console.log("Page Load Promise Resolved"))
```

AJAX
Talking Behind the Browser's Back

AJAX

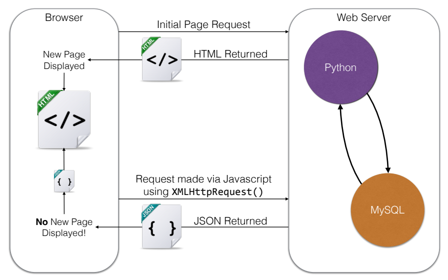
- **A**synchronous
- **J**avascript
- **A**nd
- **X**ML

AJAX

- Fortunately, almost no one uses XML anymore
- JSON is far more popular now as the format for asynchronous data
- **J**ava**S**cript **O**bject **N**otation

XMLHttpRequest

- Concept First proposed by Microsoft
- First appeared in IE 5 as an ActiveX component
- Mozilla Adopted the idea and created a Javascript implementation of it as `nsIXMLHttpRequest`. Appeared in Gecko engine in 2002
- Became the *de facto* standard when WebKit implemented it in 2004
- W3C formally standardized it in 2006



XMLHttpRequest Demo

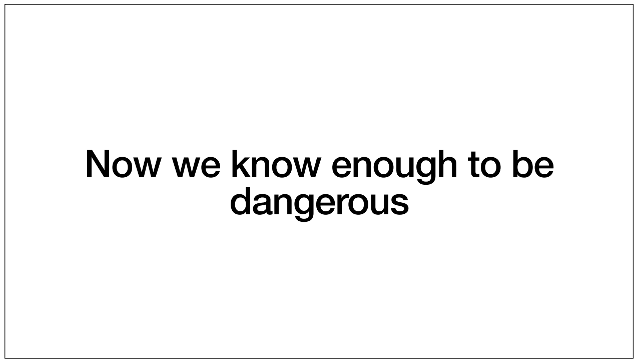
https://www2.cs.arizona.edu/classes/cs346/spring24/docs/examples/ajax-demo/

New fetch API

So much simpler

- We can finally put together all our function and Promise knowledge

```
fetch(apiURL)
    .then((responsePromise) => responsePromise.json())
    .then((responseObj) => process(responseObj))
```



Now we know enough to be dangerous