JavaScript Fundamentals

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Introduction to This Course

The source code for this course can be found at the following URL:

https://github.com/devalot/webdev

What's In Store

Day 1	Day 2
JavaScript Basics	Manipulating Web Pages
Debugging in the Browser	Event Handling
Exception Handling	Networking (AJAX)
Regular Expressions	Serialization w/ JSON

Course Requirements

Developer Tools

Please ensure that the following software applications are installed on the computer you'll be using for this course:

- Node.js LTS
- Google Chrome

Text Editor or IDE

You will also need a text editor or IDE installed. If you don't have a preferred text editor you may be interested in one of the following:

- Visual Studio Code
- Atom
- Sublime Text

Websites

Finally, ensure that your network/firewall allows you to access the following web sites:

- Devalot.com

  Handouts, slides, and course source code.

- npmjs.com

  For installing Node.js packages (if necessary).

- GitHub.com

  Class-specific updates to the course source code.

- JSFiddle

  Fast prototyping and experimenting.

- Mozilla Developer Network

  Excellent documentation for HTML, CSS, and JavaScript

Chapter 1

JavaScript the Language

1.1 Introduction to JavaScript

1.1.1 Approaching JavaScript

- JavaScript might be an object-oriented language with "Java" in the title, but it's not Java.
- I find that it's best to approach JavaScript as a functional (yet imperative) language with some object-oriented features.

1.1.2 A Little Bit About JavaScript

- Standardized as ECMAScript
  - 5th Edition, 2009 (widely supported)
  - 6th Edition, 2015 (not so much)
  - 7th Edition, 2016
  - 8th Edition, 2017
- Special-purpose language
- Dynamically typed (with weak typing)
- Interpreted and single threaded
- Prototype-base inheritance (vs. class-based)
- Nothing really to do with Java
- Weird but fun

1.1.3 Not a General Purpose Language

- JavaScript is **not** a general-purpose language
- There are no functions for reading from or writing to files
- I/O is heavily restricted

1.1.4 But, It's Not Just for the Browser

- Outside of the browser there are libraries that help make JavaScript act like a general purpose language.
- Tools such as Node.js add missing features to JS
- Weigh the pros and cons of using JS outside the browser

1.1.5 Why JavaScript?

- It's the language of the web
- Runs in the browser, options to run on server
- Easy to learn partially
- Harder to learn completely

1.1.6 JavaScript Syntax Basics

- Part of the "C" family of languages
- Whitespace is insignificant (including indentation)
- Blocks of code are wrapped with curly braces: `{ ... }`
- Expressions are terminated by a semicolon: `;`

You might also want to a reference page on Lexical Structure and Keywords in JavaScript.

1.1.7 A Note About Semicolons

- Semicolons are used to terminate expressions.
- They are optional in JavaScript.
- Due to the minification process and other subtle features of the language, you should always use semicolons.
- When in doubt, use a semicolon.

1.1.8 The Browser's JavaScript Console

- Open your browser's debugging console:
  - Command-Option-J on a Mac
  - F12 on Windows and Linux
- Enter the following JavaScript:

  ```
  console.log("Hello World");
  ```

1.1.9 Simple Console Debugging

- The browser's "console" is a line interpreter (REPL)
- All major browsers are converging to the same API for console debugging
- Can use it to set breakpoints
- Lets you see scoped variables and context
- Can set a conditional breakpoint
- `console.log` is equivalent to `printf`

1.2 Values and Operators

1.2.1 Primitive Values vs. Objects

- Primitive Values:

  ```
  "Hello World"; // Strings
  42;            // Numbers
  true && false; // Boolean
  null;          // No value
  undefined;     // Unset
  ```

- Objects (arrays, functions, etc.)

1.2.2 Variables in JavaScript

```
var x;          // undefined
var y = "Foo";  // String
var z = 5;      // Number
```

1.2.3 Declaring and Initializing Variables

- Declare variables to make them local:

  ```
  var x;
  ```

- You can initialize them at the same time:

  ```
  var n = 1;

  var x, y=1, z;
  ```

- If you don't declare a variable with `var`, the first time you assign to an undefined identifier it will become a global variable.
- If you don't assign a value to a new variable it will be `undefined`

1.2.4 Variable Naming Conventions

- Use camelCase: `userName`, `partsPerMillion`
- Allowed: letters, numbers, underscore, and `$`
- Don't use JavaScript keywords as variable names
- Always start with a lowercase letter

(All identifiers can be made up of valid Unicode characters. Don't go crazy, not all browsers support this. Stick to UTF-8 identifiers.)

1.2.5 `undefined` and `null`

- There are two special values: `null` and `undefined`
- Variables declared *without* a value will start with `undefined`
- Setting a variable to `null` usually indicates "no appropriate value"

1.2.6 Numbers

- All numbers are 64bit floating point
- Integer and decimal (`9` and `9.8` use the same type)
- Keep an eye on number precision:

  ```
  0.1 + 0.2 == 0.3; // false
  ```

- Special numbers: `NaN` and `Infinity`

```
NaN == NaN; // false
1 / 0;      // Infinity
```

1.2.7 How Do You Deal with Numeric Accuracy?

- Use a special data type like Big Decimal.
- Round to a fixed decimal place with `num.toFixed(2);`
- Only use integers (e.g., for money, represent as cents)

1.2.8 Strings

- Use double or single quotes (no difference between them):

  ```
  "Hello" // Same as...
  'Hello'
  ```

- Typical backslash characters works (e.g., `\n` and `\t`) in both types of strings.
- Operators:

  ```
  "Hello" + " World";  // "Hello World"
  "Lucky " + 21;       // "Lucky 21"
  "Lucky " - 21;       // NaN
  "1" - 1              // 0
  ```

1.2.9 Value Coercion

- JavaScript is loosely typed (uni-typed)
- Implicit conversion between "types" as needed
- Usually in unexpected ways:

  ```
  8 * null; // 0

  null > 0;  // false
  null == 0; // false
  null >= 0; // true
  ```

1.2.10 JavaScript Comments

- Single-line comments:

```
// Starts with two slashes, runs to end of line.
```

- Multiple-line comments:

```
/* Begins with a slash and asterisk.

Also a comment.

Ends with a asterisk slash. */
```

1.2.11 Exercise: Using Primitive Types

1. Open the following file:

   `src/www/js/primitives/primitives.js`
2. Complete the exercise.
3. Run the tests by opening the `index.html` file in your browser.

1.2.12 JavaScript Operators

Arithmetic	`+`	`-`	`*`	`/`	`%`	`**`	
Shortcut	`+=`	`-=`	`*=`	`/=`	`%=`	`**=`	
Inc/Dec	`++n`	`n++`	`--n`	`n--`			
Bitwise	`~`	`&`	`|`	`^`	`>>`	`<<`	`>>>`
Comparison	`>`	`>=`	`<`	`<=`			
Equality	`==`	`!=`	`===`	`!==`			
Logic	`!`	`&&`	`||`				
Object	`.`	`[]`					
String	`+`						

(Most operators have assignment shortcut versions.)

1.3 Equality in JavaScript

1.3.1 Sloppy Equality

- The traditional equality operators in JS are sloppy
- That is, they do implicit type conversion

```
"1" == 1;    // true
[3] == "3"; // true
```

```
0 != "0";  // false
0 != "";   // false
```

1.3.2 Strict Equality

More traditional equality checking can be done with the `===` operator:

```
"1" === 1;  // false
0 === "";   // false

"1" !== 1;  // true
[0] !== ""; // true
```

(This operator first appeared in ECMAScript Edition 3, circa 1999.)

1.3.3 Same-Value Equality

Similar to "`===`" with a few small changes:

```
Object.is(NaN, NaN); // true

Object.is(+0, -0);   // false
```

(This function first appeared in ECMAScript Edition 6, 2015.)

1.4 Boolean Values and Logic Operators

1.4.1 What Is `true` and What Is `false`?

- Things that are `false`:

  ```
  false;
  null;
  undefined;
  ""; // The empty string
  0;
  NaN;
  ```

- Everything else is `true`, including:

  ```
  "0";       // String
  "false";   // String
  [];        // Empty array
  ```

```
    {};        // Empty object
    Infinity; // Yep, it's true
```

1.4.2 Boolean Operators: `&&` (Conjunction)

`a && b` returns either `a` or `b` and short circuits:

```
if (a) {
  return b;
} else {
  return a;
}
```

1.4.3 Boolean Operators: `||` (Disjunction)

`a || b` returns either `a` or `b` and short circuits:

```
if (a) {
  return a;
} else {
  return b;
}
```

1.4.4 Boolean Operators: `!`

Boolean negation: `!`:

```
var x = false;
var y = !x; // y is true
```

Double negation: `!!`:

```
var n = 1;
var y = !!n; // y is true
```

1.4.5 Exercise: Boolean Operators

- Experiment with `&&`:

  ```
  0 && console.log("Yep");
  1 && console.log("Yep");
  ```

- Experiment with `||`:

  ```
  0 || console.log("Yep");
  1 || console.log("Yep");
  ```

1.4.6 Conditional Statements

```
if (expression) { then_part; }

if (expression) {
  then_part;
} else {
  else_part;
}
```

1.4.7 Chaining Conditionals

Shorthand:

```
if (expression) {
  then_part;
} else if (expression2) {
  second_then_part;
} else {
  else_part;
}
```

Long form:

```
if (expression) {
  then_part;
} else {
  if (expression2) {
    second_then_part;
  } else {
    else_part;
  }
}
```

1.4.8 Switch Statements

Cleaner conditional (using strict equality checking):

```
switch (expression) {
  case val1:
    then_part;
    break;

  case val2:
    then_part;
    break;

  default:
    else_part;
    break;
}
```

Don't forget that `break;` statement!

1.4.9 The Major Looping Statements

- Traditional `for`:

  ```
  for (var i=0; i<n; ++i) { /* body */ }
  ```

- Traditional `while`:

  ```
  while (condition) { /* body */ }
  ```

- Traditional `do ... while`:

  ```
  do { /* block */ } while (condition)
  ```

- Object Property Version of `for`:

  ```
  for (var prop in object) { /* body */ }
  ```

1.4.10 Traditional for Loops

- Just like in C:

  ```
  for (var i=0; i<10; ++i) {
    // executes 10 times.
  }
  ```

- Loops can be labeled and exited with `break`.
- Use `continue` to skip to the next iteration of the loop.

1.4.11 Traditional while Loops

```
var i=0;

while (i<10) {
  ++i;
}
```

1.4.12 Flipped while Loops

```
var i=0;

do {
  ++i;
} while (i<10);
```

1.4.13 Controlling a Loop

- Loops can be labeled and exited with `break`.

  ```
  for (var i=1; i<100; ++i) {
    if (i % 2 === 0) break;
    console.log(i);
  }
  // prints 1
  ```

- Use `continue` to skip to the next iteration of the loop.

  ```
  for (var i=1; i<100; ++i) {
    if (i % 2 === 0) continue;
    console.log(i);
  }
  // prints 1, 3, 5, 7, etc.
  ```

1.4.14 The Ternary Conditional Operator

- JavaScript supports a ternary conditional operator:

  ```
  condition ? then : else;
  ```

- Example:

  ```
  var isWarm; // Is set to something unknown.
  var shirt = isWarm ? "t-shirt" : "sweater";
  ```

1.4.15 Exercise: Experiment with Control Flow

1. Open the following file:

   `src/www/js/control/control.js`

2. Complete the exercise.
3. Run the tests by opening the `index.html` file in your browser.

1.5 Objects

1.5.1 A Collection of Key/Value Pairs

- Built up from the core types
- A dynamic collection of **properties**:

```
var box = {
  color: "tan",
  height: 12
};

box.color;              // Getter method
box.color = "red";      // Setter method

var x = "color";
box[x];           // "red"
box[x] = "blue"; // Alternative syntax
```

1.5.2 Object Basics

- Everything is an object (almost)
- Primitive types have object wrappers (except `null` and `undefined`)
- They remain primitive until used as objects, for performance reasons
- An object is a dynamic collection of properties
- Properties can be functions

1.5.3 Object Properties

There are four primary ways to work with object properties:

1. Dot notation:

   ```
   object.property = "foo";
   var x = object.property;
   ```

2. Square bracket notation:

   ```
   object["property"] = "foo";
   var x = object["property"];
   ```

3. Through the `Object.defineProperty` function
4. Using the `delete` function

1.5.4 Property Descriptors

- Object properties have descriptors that affect their behavior
- For example, you can control whether or not a property can be deleted or enumerated

- Typically, descriptors are hidden, use `defineProperty` to change them:

  ```
  var obj = {};

  Object.defineProperty(obj, "someName", {
    configurable: false, // someName can't be deleted
    enumerable:   false, // someName is hidden
    writable:     false, // No setter for someName
    // ...
  });
  ```

For more information on property descriptors,
see this MDN article.

1.5.5 Object Reflection

Objects can be inspected with…

- the `typeof` operator:

  ```
  typeof obj;
  ```

- the `in` operator:

  ```
  "foo" in obj;
  ```

- the `hasOwnProperty` function:

  ```
  obj.hasOwnProperty("foo");
  ```

Keep in mind that objects "inherit" properties. Use the `hasOwnProperty` to see if an object actually has its own copy of a property.

1.5.6 The typeof Operator

Sometimes useful for determining the type of a variable:

```
typeof 42;         // "number"
typeof NaN;        // "number"
typeof Math.abs;   // "function"
typeof [1, 2, 3]; // "object"
typeof null;       // "object"
typeof undefined; // "undefined"
```

(But not all that useful in reality.)

Instead of doing this:

```
if (typeof someVal === "undefined") {
  // ...
}
```

Just do:

```
if (someVal === undefined) {
  // ...
}
```

1.5.7 Property Enumeration

- The `for..in` loop iterates over an object's properties in an **unspecified** order.
- Use `object.hasOwnProperty(propertyName)` to test if a property is inherited or local.

```
for (var propertyName in object) {
   /*
     propertyName is a string.

     Must use this syntax:
     object[propertyName]

     Does not work:
     object.propertyName
  */
}
```

1.5.8 Object Keys

- Get an array of all "own", enumerable properties:

  ```
  Object.keys(obj);
  ```

- Get even non-enumerable properties:

  ```
  Object.getOwnPropertyNames(obj);
  ```

1.5.9 Object References and Passing Style

- Objects can be passed to and from functions
- JavaScript is **call-by-sharing** (very similar to call-by-reference)

- Watch out for functions that modify your objects!
- Remember that `===` compares references
- Since `===` only compares references, it only returns `true` if the two operands are the same object in memory
- There's no built in way in JS to compare objects for similar contents

1.5.10 JavaScript and Mutability

- All primitives in JavaScript are immutable
- Using an assignment operator just creates a new instance of the primitive
- You can think of primitives as using **call-by-value**
- Unless you used an object constructor for a primitive!
- Objects are mutable (and use **call-by-sharing**)
- Their values (properties) can change

1.5.11 Exercise: Create a `copy` Function

1. Open the following file:

   `src/www/js/copy/copy.js`

2. Complete the exercise.
3. Run the tests by opening the `index.html` file in your browser.

Hints:

- `for (var prop in someobj) { /* ... */ }`
- `someobj.hasOwnProperty(prop)`

1.5.12 The `Object.assign` Function

Copies properties from one object to another:

```
var o1 = {a: 1, b: 2, c: 3};
var o2 = { };

Object.assign(o2, o1);
console.log(o2);
```

Produces this output:

```
{ a: 1, b: 2, c: 3 }
```

(This function first appeared in ECMAScript Edition 6, 2015.)

1.6 Builtin Objects

1.6.1 The String Object

- 16 bit unicode characters (UCS-2, not quite UTF-16)
- Single or double quotes (no difference)
- Similar strings are `===` equal (checks contents)
- `>=` ES5 supports multiple line literals using a backslash

1.6.2 String Properties and Instance (Prototype) Methods

- `str.length`
- `str.charAt(i);`
- `str.concat();`
- `str.indexOf(needle);`
- `str.slice(iStart, iEnd);`
- `str.substr(iStart, length);`
- `str.replace(regex|substr, newSubStr|function);`
- `str.toLowerCase();`
- `str.trim();`

1.6.3 The Number Object

- Constants:
  - `Number.MAX_VALUE`
  - `Number.NaN`
  - `Number.POSITIVE_INFINITY`
  - etc.
- Generic Methods:
  - `Number.isInteger(n);`
  - `Number.isFinite(n);`
  - `Number.parseFloat(s);`
  - `Number.parseInt(s);`
- Prototype Methods:

  - `num.toString();`
  - `num.toFixed();`
  - `num.toExponential();`

1.6.4 The Math Object

- Constants:
  - `Math.E`
  - `Math.LOG2E`
  - `Math.PI`
  - etc.
- Generic Functions:
  - `Math.abs(n);`
  - `Math.pow(n, e);`
  - `Math.sqrt(n);`
  - etc.

1.6.5 The Date Object

- An instance of the Date object is used to represent a point in time
- Must be constructed:

```
var d = new Date(); // current date
var d = new Date("Wed, 28 Jan 2015 13:30:00 MST");
```

- Months start at 0, days start at 1
- Timestamps are unix time:

```
d.getTime(); // 1422477000000
```

1.6.6 The Date Object (functions)

- Generic Methods:
  - `Date.now();`
  - `Date.UTC();`
  - `Date.parse("March 7, 2014");`
- Prototype Methods:

```
var d = new Date();

d.getMonth();
d.getHours();
d.getMinutes();
```

```
d.getFullYear(); // Don't use d.getYear();
d.setYear(1990);
```

1.6.7 The Array Object

- Arrays are objects that behave like traditional arrays
- Use arrays when order of the data should be sequential

1.6.8 The Array Object (Examples)

- Creating Arrays:

  ```
  // Array literal:
  var myArray = [1, 2, 3];

  // Using the constructor function:
  var myArray = new Array(1, 2, 3);
  ```

- Functions/Methods:

  ```
  var a = [1, 2, 3];
  a.length; // 3
  Array.isArray(a); // true (>= ES5)
  typeof a; // "object" :(
  ```

1.6.9 Array Cheat Sheet

- Insert: `a.unshift(x);` or `a.push(x);`
- Remove: `a.shift();` or `a.pop();`
- Combine: `var b = a.concat([4, 5]);`
- Extract: `a.slice(...);` or `a.splice(...);`
- Search: `a.indexOf(x);`
- Sort: `a.sort();`

1.6.10 Array Enumeration

WARNING: Use `for`, not `for...in`. The latter doesn't keep array keys in order!

```
for (var i=0; i < myArray.length; ++i) {
  // myArray[i]
}
```

Chapter 2

Debugging

2.1 Debugging in the Browser

2.1.1 Introduction to Debugging

- All modern browsers have built-in JavaScript debuggers
- We've been using the debugging console the entire time!

2.1.2 Browser Debugging with the Console

- The `console` object:
  - Typically on `window` (doesn't always exist)
  - Methods
    - `log`, `info`, `warn`, and `error`
    - `table(object)`
    - `group(name)` and `groupEnd()`
    - `assert(boolean, message)`

2.1.3 Accessing the Debugger

- In the browser's debugging window, choose **Sources**
- You should be able to see JavaScript files used for the current site

2.1.4 Setting Breakpoints

There are a few ways to create breakpoints:

- Open the source file in the browser and click a line number
- Right-click the line number to create conditional breakpoints
- Use the `debugger;` statement in your code

2.1.5 Stepping Through Code

- After setting breakpoints, you can reload the page (or trigger a function)
- Once the debugger stops on a breakpoint you can step through the code using the buttons in the debugger
  - Step In: Jump into the current function call and debug it
  - Step Over: Jump over the current function call
  - Step Out: Jump out of the current function

2.1.6 Console Tricks

- `$_` the value of the last evaluation
- `$0`—`$4` last inspected elements in historical order
- `$("selector")` returns first matching node (CSS selector)
- `$$("selector")` returns all matching nodes
- `debug(function)` sets a breakpoint in `function`
- `monitor(function)` trace calls to `function`

See the Chrome Command Line Reference for more details.

Chapter 3

Functions

3.1 Functions

3.1.1 Introduction to Functions

- “The best part of JavaScript”
- Functions are used to implement **many** features in JS:
  - Classes, constructors, and methods
  - Modules, namespaces, and closures
  - And a whole bunch of other stuff

3.1.2 Defining a Function

There are several ways of defining functions:

- Function statements (named functions)
- Function expression (anonymous functions)
- Arrow functions (new in ES2015)

3.1.3 Function Definition (Statement)

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

var result = add(1, 2); // 3
```

- This syntax is know as a **function definition statement**. It is only allowed where statements are allowed. This is when the distinction between statements and expressions becomes important.
- Most of the time you should use the expression form of function definition.

3.1.4 Function Definition (Expression)

```
var add = function(a, b) {
  return a + b;
};

var result = add(1, 2); // 3
```

- Function is callable through a variable
- Name after `function` is optional
- We'll see it used later

3.1.5 Function Invocation

- Parentheses are mandatory in JavaScript for function invocation
- Any number of arguments can be passed, regardless of the number defined
- Extra arguments won't be bound to a name
- Missing arguments will be `undefined`

3.1.6 Function Invocation (Example)

```
var add = function(a, b) {
  return a + b;
};

add(1)       // a is 1, b is undefined
add(1, 2)    // a is 1, b is 2
add(1, 2, 3) // No name for 3.
```

3.1.7 Function Invocation and Parentheses

```
var add = function(a, b) {return a + b;};

var x = add;        // x is now a function object
```

```
x(1, 2);           // Same as add(1, 2);

var y = add(1, 2); // y is 3
```

3.1.8 Functions that Return a Value

In order for a function to return a value to its caller, it must use the `return` keyword.

```
var add = function(a, b) {
  // WRONG!  Computes a sum then throws it away.
  a + b;
};
```

vs.

```
var add = function(a, b) {
  return a + b; // CORRECT!
};
```

3.1.9 Be Careful with Your Line Breaks

This:

```
var f = function(a, b) {
  return
    a + b;
};
```

Turns into:

```
var f = function(a, b) {
  return;
  a + b;
};
```

Instead, write:

```
var f = function(a, b) {
  return a +
    b;
};
```

3.1.10 Special Function Variables

Functions have access to two special variables:

- `arguments`: An object that encapsulates all function arguments
- `this`: The object the function was called through

3.1.11 Rules for Using the `arguments` Variable

- Access all arguments, even unnamed ones
- Array-like, but not an actual array
- Only has `length` property
- Should be treated as read-only (never modify!)
- To treat like an array, convert it to one

```
var arr = Array.prototype.slice.call(arguments);
```

or, slightly more popular (but wasteful):

```
var arr = [].slice.call(arguments);
```

or, with ES6:

```
var args = Array.from(arguments);
```

3.1.12 Built-in Functions (Types and Conversions)

`isNaN(num)`: Safely test if `num` is `NaN`
`isFinite(num)`: Test if `num` is **not** `NaN` or `Infinity`
`parseInt(str)`: Convert a string to a number (integer)
`parseFloat(str)`: Convert a string to a number (float)

3.1.13 Exercise: Function Arguments and Parsing

1. Open the following file:

   `src/www/js/parse/parse.js`

2. Complete the exercise.
3. Run the tests by opening the `index.html` file in your browser.

3.1.14 Variable Scope

- **Scope** refers to how long a variable is alive and what code can see it
- There are basically two types of scope: **global** and **local**
- Functions are the only way to create a new local scope (with a few exceptions)
- If you don't use `var` then variables are **global**

3.1.15 Example: Identify the Scope For Each Variable

```
var a = 5;

function foo(b) {
  var c = 10;
  d = 15;

  if (d === c) {
    var e = "error: wrong number";
    console.log(e);
  }

  var bar = function(f) {
    var c = 2;
    a = 12;
    return a + c + b;
  };
}
```

- Three scopes exists in the above example
- Variables `a` and `d` are global
- There are two independent local variables named `c`
- Variable `bar` is a local variable containing a function
- Variables `b`, `e`, and `f` are local to their respective functions
- Each inner scope has access to the outer, but the outer scopes cannot access the inner ones
- `ReferenceError` indicates that a variable wasn't found in the current scope chain

3.1.16 Scope Tips

- Avoid using (and polluting) the global scope
- Use scoping to create namespaces (modules) your code
- You can "hide" things by wrapping them in a function
- Closures are born out of using lexical scope
- We'll see more of this later…
- No block scope

3.2 Variable Hoisting

When using the `var` keyword, only functions can introduce a new variable scope. This leads to something known as hoisting.

3.2.1 Exercise: Hoisting (Part 1 of 2)

What will the output be?

```
function foo() {
  x = 42;
  var x;

  console.log(x); // ?
  return x;
}
```

3.2.2 Answer: Hoisting (Part 1 of 2)

This:

```
function foo() {
  x = 42;
  var x;

  console.log(x); // ?
  return x;
}
```

Turns into:

```
function foo() {
  var x;
  x = 42;

  console.log(x);
  return x;
}
```

3.2.3 Exercise: Hoisting (Part 2 of 2)

And this one?

```
function foo() {
  console.log(x); // ?
  var x = 42;
}
```

3.2.4 Answer: Hoisting (Part 2 of 2)

This:

```
function foo() {
  console.log(x); // ?
  var x = 42;
}
```

Turns into:

```
function foo() {
  var x;
  console.log(x);
  x = 42;
}
```

3.2.5 Explanation of Hoisting

- Hoisting refers to when a variable declaration is lifted and moved to the top of its scope (only the declaration, not the assignment)
- Function statements are hoisted too, so you can use them before actual declaration
- JavaScript essentially breaks a variable declaration into two statements:

  ```
  var x=0, y;

  // Is interpreted as:
  var x=undefined, y=undefined;
  x=0;
  ```

3.3 Functional Programming with Arrays

3.3.1 Introducing Higher-order Functions

The `forEach` function is a good example of a *higer-order* function:

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

a.forEach(function(val, index, array) {
  // Do something...
});
```

Or, less idiomatic:

```
var f = function(val) { /* ... */ };
a.forEach(f);
```

3.3.2 Array Testing

- Test if a function returns `true` on all elements:

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

a.every(function(val) {
  return val > 0;
});
```

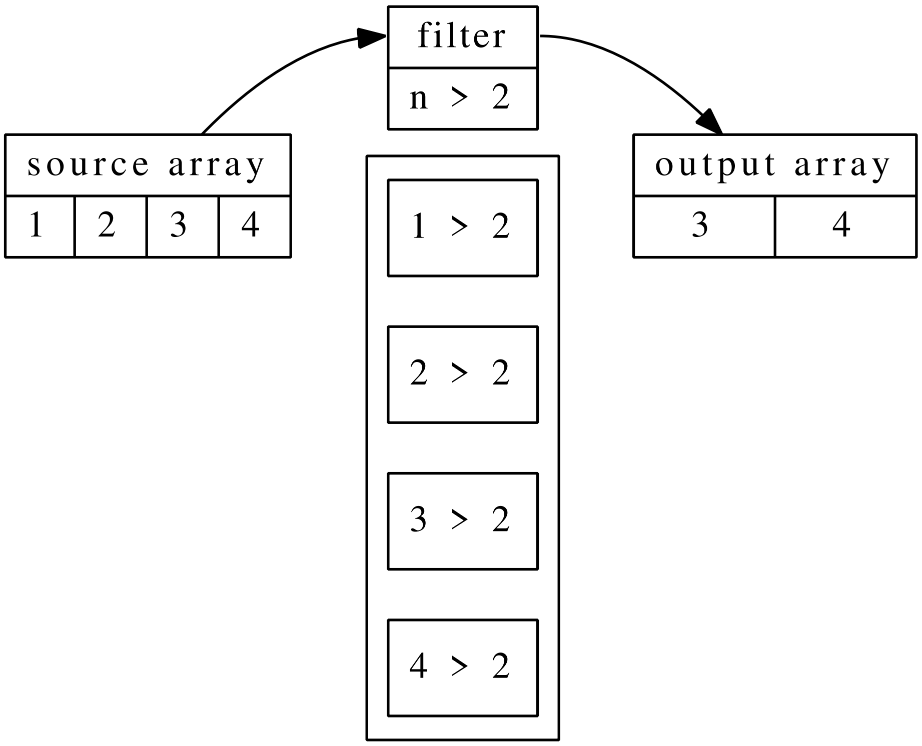
- Test if a function returns `true` at least once:

```
a.some(function(val) {
  return val > 2;
});
```

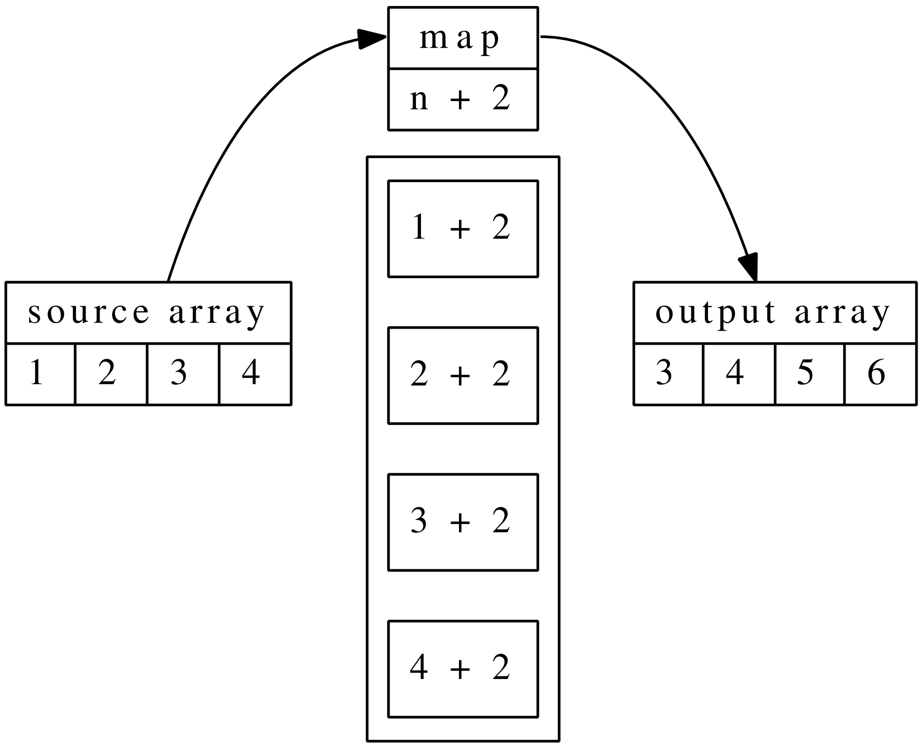
3.3.3 Higher-order Array Functions

- `a.filter(f);`: New array filtered with a predicate `f`
- `a.map(f);`: New array after transforming with `f`
- `a.reduce(f);`: **Fold** an array into something else using `f`

3.3.4 Filtering an Array with a Predicate Function



3.3.5 Mapping a Function Over an Array



3.3.6 Example: Folding an Array with `reduce`

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

// Sum numbers in `a'.
var sum = a.reduce(function(acc, elm) {
  // 1. `acc' is the accumulator
  // 2. `elm' is the current element
  // 3. You must return a new accumulator
  return acc + elm;
}, 0);
```

3.3.7 Exercise: Arrays and Functional Programming

1. Open the following file:

   `src/www/js/array/array.js`

2. Complete the exercise.
3. Run the tests by opening the `index.html` file in your browser.

Hint: Use https://developer.mozilla.org/ for documentation.

3.4 Common Patterns Involving Functions

3.4.1 Anonymous Functions

- A function expression without a name:

  ```
  var anon = function() {};
  ```

- Pros:
  - Powerful
  - Functions can be passed as arguments
  - Defined inline
- Cons:
  - Difficult to test in isolation
  - Discourages code re-use

3.4.2 Anonymous Functions (Tips)

- Name your anonymous functions for debugging

  ```
  numbers.forEach(function foo(e) {
    console.log(e);
  });
  ```

- Name is scoped to the inside of the anonymous function so it can refer to itself, easier to debug; errors reference the function name

3.4.3 Functions as Callbacks

- When a function is provided as an argument as something to be invoked inline, or under specific circumstances (like an event):

  ```
  function runCallback(callback) {
    // does things
    return callback();
  }
  ```

- Functions that take functions as arguments are called *higher-order* functions.

3.4.4 Functions as Timers

- Establish delay for function invocation:

  ```
  // setTimeout(func, delayInMs[, arg1, argn]);
  var timer = setTimeout(func, 500);
  ```

- Use `clearTimeout(timer)` to cancel
- Establish an interval for periodic invocation

  ```
  setInterval(func, ms);
  clearInterval(timer);
  ```

3.5 Function Closures

3.5.1 Closures: Basics

- One of the most important features of JavaScript
- And often one of the most misunderstood & feared features
- But, they are all around you in JavaScript
- Happens automatically when you use function expressions

3.5.2 Closures: Definitions

- Bound variable: local variables created with `var` or `let` are said to be *bound*.
- Free variable: Any variable that isn't bound and isn't a global variable is called a *free* variable.
- A function that uses free variables *closes around* them, capturing them in a *closure*.
- A closure is a new scope for free variables.

3.5.3 Closures: Example

```
function outer() {
  var name = "Grim";
```

```
  var inner = function() {
    console.log(name);
  };

  return inner;
}

// Invoke `outer' and get a function back:
var f = outer();

// Sometime in the future...
f();
```

See: `src/examples/js/closure.html`

3.5.4 Closures: Practical Example

```
var Foo = function() {

  var privateVar = 42;

  var getter = function() {
    return privateVar;
  };

  return {
    getPrivateVar: getter,
  };
};

var x = Foo();
x.getPrivateVar(); // 42
```

3.5.5 Exercise: Sharing Scope

1. Open the following file:

   `src/www/js/closure/closure.js`

2. Complete the exercise.

3. Run the tests by opening the `index.html` file in your browser.

3.5.6 Loops and Closures

- Be careful with function expressions in loops
- They can have scope issues:

```
// What will this output?
for (var i=0; i<3; i++) {
  setTimeout(function(){
    console.log(i);
  }, 1000*i);
}
console.log("Howdy!");
```

Chapter 4

Object-Oriented Programming

4.1 Scope and Context

4.1.1 Adding Context to a Scope

- We already discussed **scope**
  - Determines visibility of variables
  - Lexical scope (location in source code)
- There is also **context**
  - Refers to the location a function was invoked
  - Dynamic, defined at runtime
  - Context is accessible as the `this` variable

4.1.2 Context Example

```
var apple  = {name: "Apple",  color: "red"   };
var orange = {name: "Orange", color: "orange"};

var logColor = function() {
  console.log(this.color);
};

apple.logColor  = logColor;
orange.logColor = logColor;
```

```
apple.logColor();
orange.logColor();
```

4.1.3 Context and the `this` Keyword

- The `this` keyword is a reference to "the object of invocation"
- Bound at invocation (depends on the call site)
- Allows a method to reference the "current" object
- A single function can then service multiple objects
- Central to prototypical inheritance in JavaScript

4.1.4 How JavaScript Sets the `this` Variable

- Resides in the global binding
- Inner functions do not capture parent's `this` (there are several workarounds such as `var self = this;`, `bind`, and ES6 arrow functions)
- The `this` object can be set manually! (Take a look at the `call`, `apply`, and `bind` functions.)

4.2 Constructor Functions

4.2.1 Constructor Functions and the `new` Operator

What's going on when you use `new`?

```
var m = new Message("pjones@devalot.com", "Hello");
m.send(); // calls `Message.prototype.send'
          // with `this' set to `m'
```

4.2.2 Writing a Constructor Function

```
var Message = function(sender, content) {
  this.sender  = sender;
  this.content = content;
};
```

```
Message.prototype.send = function() {
  if (this.content.length !== 0) {
    console.log(this.sender, this.content);
  }
};
```

4.2.3 The `new` Keyword

```
var m = new Message("pjones@devalot.com", "Hello");
m.send(); // calls `Message.prototype.send'
          // with `this' set to `m'
```

The `new` operator does the following:

1. Creates a new, empty object
2. Sets up inheritance for the object and records which function constructed the object.
3. Calls the function given as its operand, setting `this` to the newly created object

4.2.4 Implementing a Fake `new` Operator

```
var fakeNew = function(func) {
  // Step 1. Create an object with proper inheritance:
  var newObject = Object.create(func.prototype);

  // Step 2. Invoke the constructor:
  func.call(newObject);

  // Step 3. Return the new object:
  return newObject;
};
```

4.2.5 Exercise: Constructor Functions

1. Open the following file:

   `src/www/js/constructors/constructors.js`

2. Complete the exercise.
3. Run the tests by opening the `index.html` file in your browser.

4.3 Factory Functions

4.3.1 Factory Functions (Hand-made Constructors)

```
var Message = function(sender, content) {
  var m = Object.create(Message.prototype);

  m.sender  = sender;
  m.content = content;
  m.length  = content.length;

  return m;
};

Message.prototype = { /* ... */ };

var message = Message("pjones@devalot.com", "Hello");
```

Chapter 5

Exceptions

5.1 Exception Handling

Handling errors in JavaScript is done through exceptions. Programmers familiar with Java or C++ will feel (mostly) comfortable with JavaScript's exception system.

5.1.1 Exception Basics

- Errors in JavaScript propagate as exceptions
- Dealing with errors therefore requires an exception handler
- Keywords for exception handling:
  - `try`: Run code that might throw exceptions
  - `catch`: Capture a propagating exception
  - `throw`: Start exception processing
  - `finally`: Resource clean-up handler

5.2 Throwing Exceptions

5.2.1 Example: Throwing an Exception

When a major error occurs, use the `throw` keyword:

```
if (someBadCondition) {
  throw "Well, this is unexpected!";
}
```

5.3 Exception Objects

While you can throw exceptions with primitive types such as numbers and strings, it's more idiomatic to throw exception objects.

5.3.1 Built-in Exception Objects

- `Error`: Generic run-time exception
- `EvalError`: Errors coming from the `eval` function
- `RangeError`: Number outside expected range
- `ReferenceError`: Variable used without being declared
- `SyntaxError`: Error while parsing code
- `TypeError`: Variable not the expected type
- `URIError`: Errors from `encodeURI` and `decodeURI`

5.3.2 Creating Your Own Exception Object

This looks more traditional, but it's missing valuable information.

```
function ShoppingCartError(message) {
  this.message = message;
  this.name    = "ShoppingCartError";
}

// Steal from the `Error' object.
ShoppingCartError.prototype = Error.prototype;

// To throw the exception:
throw new ShoppingCartError("WTF!");
```

5.3.3 Custom Exceptions: The Better Way

If you start with an `Error` object, you retain a stack trace and error source information (e.g., file name and line number).

```
var error = new Error("WTF!");
error.name = "ShoppingCartError";
error.extraInfo = 42;
throw error;
```

5.4 Catching Exceptions

If you can handle an error condition thrown from code inside a `try` block then you can use a `catch` block to do so. In JavaScript you can only use a *single* `catch` statement. That means you have to catch an exception and then inspect it to see if it's the one you can handle.

5.4.1 Example: Catching Errors

```
var beSafe = function() {
  try {
    // Some code that might fail.
  }
  catch (e) {
    // Errors show up here.  All of them.
  }
};
```

5.4.2 Example: Catching Exceptions by Type

Most of the time you only want to deal with specific exceptions:

```
var beSafe = function() {
  try { /* Code that might fail. */ }
  catch (e) {
    if (e instanceof TypeError) {

      // If you're here then the error
      // is a TypeError.

    } else {
      throw e; // Re-throw the exception.
    }
  }
};
```

5.4.3 Exercise: Exceptions

1. Open the following file:

   `src/www/js/exceptions/exceptions.js`

2. Complete the exercise.

3. Run the tests by opening the `index.html` file in your browser.

Chapter 6

Regular Expressions

6.1 Introduction to Regular Expressions

6.1.1 Regular Expressions

- Patterns used to match character combinations in strings
- Very tough to understand but extremely powerful
- Useful for data validation
- JavaScript supports literals for the `RegExp` object:

  ```
  var re = /^\d+$/;
  re.test("1234"); // true
  ```

6.1.2 Expression Language Primer

Token	Meaning
`.`	Match any single character
`\w`	Match a word character
`\d`	Match a digit
`\s`	Match a space character
`\b`	Word boundary

Repeater	Meaning
`?`	Match zero or one preceding token
`*`	Match zero or more preceding tokens

Repeater	Meaning
`+`	Match one or more preceding tokens

6.2 Using Regular Expressions

6.2.1 `String` Methods That Take Regular Expressions

`str.match(re);` If the expression matches, returns an array describing what matched.

`str.replace(re);` Replace parts of a string matched by an expression.

`str.search(re);` Tests to see if the expression matches. Faster than `match` because it stops after the first match and returns `1`.

`str.split(re);` Split a string at locations matched by the expression and return
an array.

6.2.2 Exercise: String Manipulation

1. Open the following file:

   `src/www/js/regexp/regexp.js`

2. Complete the exercise.
3. Run the tests by opening the `index.html` file in your browser.

Hint: Use https://developer.mozilla.org/ for documentation.

6.3 Additional Resources on Regular Expressions

- Interactive Tool
- Cheat Sheet

Chapter 7

JavaScript and the Web Browser

7.1 Where JavaScript Fits In

7.1.1 JavaScript and the Browser

How JavaScript fits in:

- HTML for content and user interface
- CSS for presentation (styling)
- JavaScript for behavior (and business logic)

7.2 HTML Refresher

7.2.1 What is HTML?

- Hyper Text Markup Language
- HTML is very error tolerant (browsers are very forgiving)
- That said, you should strive to write good HTML
- Structure of the UI and the content of the **view data**
- Parsed as a tree of nodes (elements)
- HTML5
  - Rich feature set

  - Semantic (focus on content and not style)
  - Cross-device compatibility
  - Easier!

7.2.2 Anatomy of an HTML Element

- Also known as: nodes, elements, and tags:

```
<element key="value" key2="value2">
  Text content of element
</element>
```

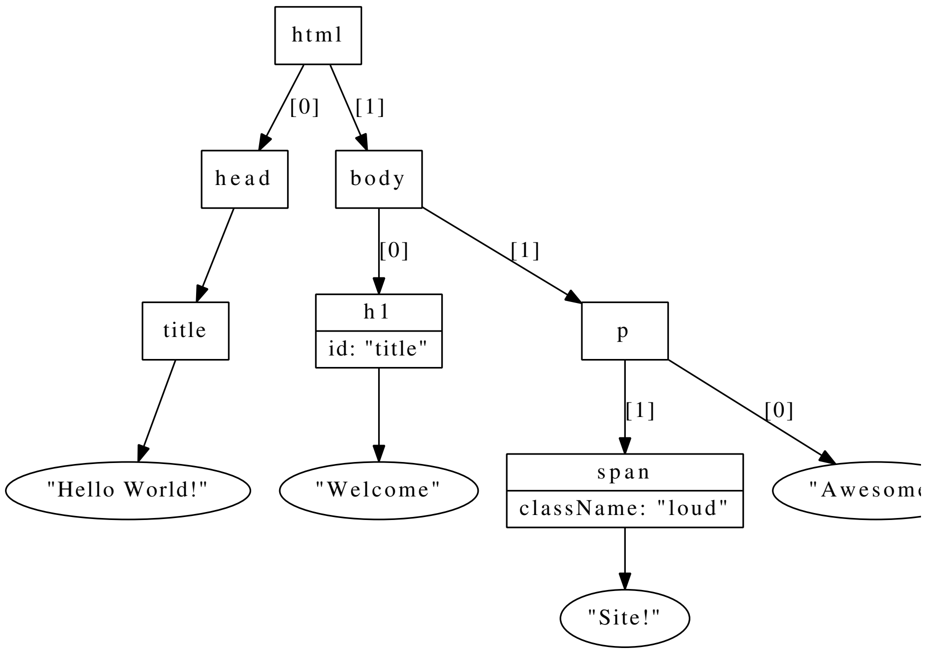
7.2.3 HTML Represented as Plain Text

```
<html>
  <head>
    <title>Hello World!</title>
  </head>

  <body>
    <h1 id="title">Welcome</h1>

    <p>
      Awesome <span class="loud">Site!</span>
    </p>
  </body>
</html>
```

7.2.4 HTML Parsed into a Tree Structure



7.3 CSS Refresher

7.3.1 What is CSS?

- Cascading Style Sheets
- Rule-based language for describing the look and formatting
- Separates presentation from content
- Can be a separate file or inline in the HTML
- Prefer using a separate file

7.3.2 What Does CSS Look Like?

```
p {
  background-color: white;
  color: blue;
  padding: 5px;
}

.spoiler {
  display: none;
}

p.spoiler {
  display: block;
  font-weight: bold;
}
```

7.3.3 Anatomy of a CSS Declaration

- Selectors choose which elements you want to style. A selector is followed by a body where styling properties are set:

  ```
  selector {
    property-x: value;
    property-y: val1 val2;
  }
  ```

- For example:

  ```
  h1 {
    color: #444;
    border: 1px solid #000;
  }
  ```

7.3.4 The Various Kinds of Selectors

- Using the element's type (name):
  - HTML: `<h1>Hello</h1>`
  - CSS: `h1 {...}`
- Using the ID attribute:
  - HTML: `<div id="header"></div>`
  - CSS: `#header {...}`
- Using the class attribute:
  - HTML: `<div class="main"></div>`
  - CSS: `.main {...}`
- Using location or relationships:
  - HTML: `<ul><li><p>One</p></li><li>Two</li></ul>`
  - CSS: `ul li p {...}`

7.4 Getting JavaScript into the Browser

7.4.1 How the Browser Processes JavaScript

- Parser continues to process HTML while downloading JS
- Once downloaded, JS is executed and *blocks* the browser
- Include the JS at the bottom of the page to prevent blocking

7.4.2 Getting JavaScript into a Web Page

- Preferred option:

  ```
  <script src="somefilename.js"></script>
  ```

- Inline in the HTML (yuck):

  ```
  <script>
    var x = "Hey, I'm JavaScript!";
    console.log(x);
  </script>
  ```

- Inline on an element (double yuck):

  ```
  <button onclick="console.log('Hey there');"/>
  ```

7.4.3 How JavaScript Affects Page Load Performance (Take Two)

- The browser blocks when executing JS files
- JS file will be downloaded then executed before browser continues
- Put scripts in file and load them at the bottom of the page

Chapter 8

The Document Object Model

8.0.1 What is the DOM?

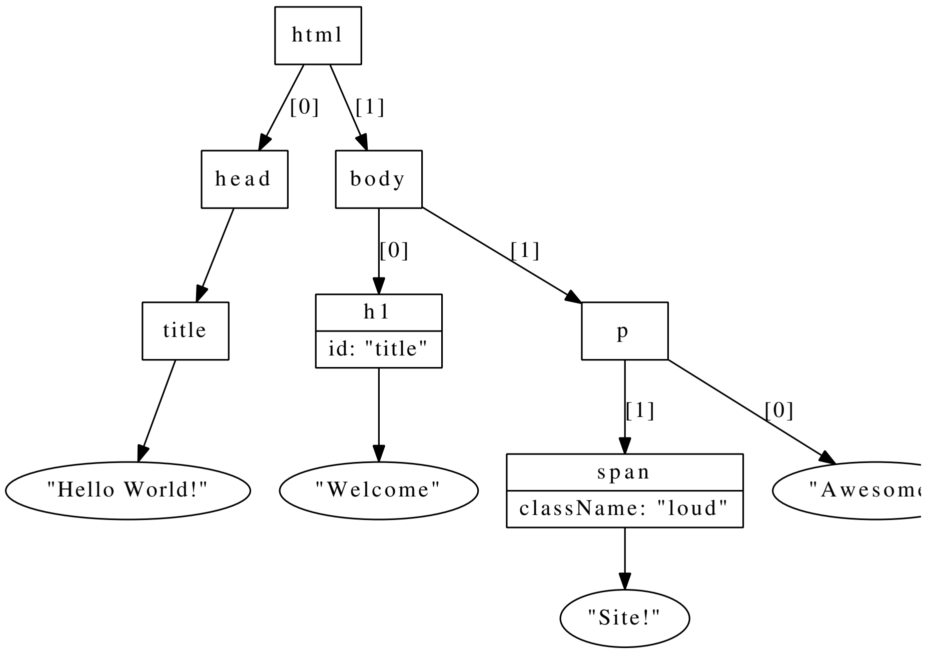
- What most people hate when they say they hate JavaScript
- The DOM is the browser's API for the document
- Through it you can manipulate the document
- Browser parses HTML and builds a tree structure
- It's a live data structure

8.0.2 The Document Structure

- The `document` object provides access to the document
- It's a tree-like structure
- Each node in the tree represents one of:
  - Element
  - Content of an element
- Relationships between nodes allow traversal

8.0.3 Looking at the Parsed HTML Tree (again)

And produce this tree structure:



8.0.4 Element Nodes

- The HTML:

```
<p id="name" class="hi">My <span>text</span></p>
```

- Maps to:

```
var node = {
  tagName:    "P",
  childNodes: NodeList,
  className:  "hi",
  innerHTML:  "My <span>text</span>",
  id:         "name",
  // ...
};
```

  – Attributes may **very loosely** to object properties

8.0.5 Working with the Document Object Model

- Accessing elements:
  – Select a single element

  - Select many elements
  - Traverse elements
- Working with elements
  - Text nodes
  - Raw HTML
  - Element attributes

8.0.6 Performance Considerations

- Dealing with the DOM brings up a lot of performance issues
- Accessing a node has a cost (especially in IE)
- Styling has a bigger cost (it cascades)
  - Inserting nodes
- Layout changes
  - Accessing CSS margins
  - Reflow
  - Repaint
- Accessing a `NodeList` has a cost

8.1 Getting References to Elements

Starting with the `document` global variable, you can access specific elements in the DOM using the following functions. Once you have a specific element you can use these functions again (with the element as the receiver) to search the DOM, which starts the search in the element's decedents.

8.1.1 Accessing Individual Elements

Starting on the `document` object or a previously selected element:

`document.getElementById("main");` Returns the element with the given ID (e.g., `<div id="main">`).

`document.querySelector("p span");` Returns the *first* element that matches the given CSS selector.
The search is done using depth-first pre-order traversal.

8.1.2 Accessing a List of Elements

Starting on the `document` object or a previously selected element:

`document.getElementsByTagName("a");` Returns a `NodeList` containing *all* `<a>` elements.

`document.getElementsByClassName("highlight");` Returns a `NodeList` containing *all* elements that have a `class` attribute set to `foo` (e.g., `<div class="highlight">`).

`document.querySelectorAll("p span");` Returns a `NodeList` containing *all* elements that match the given CSS selector.

8.2 Traversing the DOM

Once you have a single element in the DOM you can traverse from that point to somewhere else in the tree using the following read-only **properties**:

8.2.1 Traversal Functions

`parentNode` The parent of the specified element.

`previousSibling` The element immediately preceding the specified element.

`nextSibling` The element immediately following the specified element.

`firstChild` The first child element of the specified element.

`lastChild:` The last child element of the specified element.

`childNodes` A `NodeList` containing the direct decedents (children) of the specified element.

8.2.2 Traversal Example

Note: Remember that when you traverse the DOM you will encounter text nodes and comments in addition to child elements!

(1) Example: Examining the children of a node:

```
var main = document.getElementById("main");

if (main) {
  console.log("#main child count: ", main.childNodes.length);
  console.log("first child is: ", main.firstChild);
}
```

But...

8.2.3 DOM Living Standard (WHATWG)

Supported in IE >= 9:

`children`: All *element* children of a node (i.e. no text nodes).

`firstElementChild`: First *element* child.

`lastElementChild`: Last *element* child.

`childElementCount`: The number of children that are *elements*.

`previousElementSibling`: The previous sibling that is an *element*.

`nextElementSibling`: The next sibling that is an *element*.

8.3 Node Types

While traversing the DOM it's helpful to know which type of nodes you are working with. The `nodeType` property is an integer that precisely identifies the node.

8.3.1 The `nodeType` Property

Interesting values for the `element.nodeType` property:

Value	Description
1	Element node
3	Text node
8	Comment node
9	Document node

8.4 Manipulating the DOM Tree

8.4.1 Creating New Nodes

`document.createElement("a");` Creates and returns a new node without inserting it into the DOM.
In this example, a new `<a>` element is created.

`document.createTextNode("hello");` Creates and returns a new text node with the given content.

8.4.2 Adding Nodes to the Tree

```
var parent = document.getElementById("customers"),
    existingChild = parent.firstElementChild,
    newChild = document.createElement("li");
```

`parent.appendChild(newChild);` Appends `newChild` to the end of `parent.childNodes`.

`parent.insertBefore(newChild, existingChild);` Inserts `newChild` in `parent.childNodes` just before the existing child node `existingChild`.

`parent.replaceChild(newChild, existingChild);` Removes `existingChild` from `parent.childNodes` and inserts `newChild` in its place.

`parent.removeChild(existingChild);` Removes `existingChild` from `parent.childNodes`.

8.5 Node Attributes

8.5.1 Getting and Setting Node Attributes

```
var element = document.getElementById("foo"),
    name    = "bar";
```

`element.getAttribute(name);` Returns the value of the given attribute.

`element.setAttribute(name, value);` Changes the value of the given attribute name to `value`.

`element.hasAttribute(name);` Returns `true` if `element` has an attribute with the given name.

`element.removeAttribute(name);` Removes the named attribute from `element`.

8.6 The Class Attribute

8.6.1 Class Attribute API

```
var element = document.getElementById("foo"),
    name    = "bar";
```

`element.classList.add(name);` Add `name` to the list of classes in the class attribute.

`element.classList.remove(name);` Remove `name` from the list of classes in the class attribute.

`element.classList.toggle(name);` If `name` is present in the class list, remove it. Otherwise add
it to the class list.

`element.classList.contains(name);` Check to see if the class list contains `name`.

8.7 Node Content

8.7.1 HTML and Text Content

```
var element = document.getElementById("foo"),
    name    = "bar";
```

`element.innerHTML` Get or set the element's decedents as HTML.

`element.textContent:` Get or set *all* of the text nodes (including decedents) as a
single string.

`element.nodeValue` If `element` is a text node, comment, or attribute node, returns
the content of the node.

`element.value` If `element` is a form input, returns its value.

8.8 DOM Nodes: Exercises

8.8.1 Exercise: DOM Manipulation

1. Open the following files in your text editor:
   - `src/www/js/flags/flags.js`
   - `src/www/js/flags/index.html` (read only!)
2. Open the `index.html` file in your web browser.
3. Complete the exercise.

8.9 Event Handling and Callbacks

8.9.1 Events Overview

- Single-threaded, but asynchronous event model
- Events fire and trigger registered handler functions
- Events can be click, page ready, focus, submit (form), etc.

8.9.2 So Many Events!

- UI: load, unload, error, resize, scroll
- Keyboard: keydown, keyup, keypress
- Mouse: click, dblclick, mousedown, mouseup, mousemove
- Touch: touchstart, touchend, touchcancel, touchleave, touchmove
- Focus: focus, blur
- Form: input, change, submit, reset, select, cut, copy, paste

8.9.3 Using Events (the Basics)

1. Select the element you want to monitor
2. Register to receive the events you are interested in
3. Define a function that will be called when events are fired

8.9.4 Event Registration

Use the `addEventListener` function to register a function to be called when an event is triggered:

Example: Registering a click handler:

```
var main = document.getElementById("main");

main.addEventListener("click", function(event) {
  console.log("event triggered on: ", event.target);
});
```

Note: Don't use older event handler APIs such as `onClick`!

See this reference for a list of all event types.

8.9.5 Event Handler Call Context

- Functions are called in the context of the DOM element
- I.e., `this === eventElement`
- Use `bind` or the `var self = this;` trick

8.9.6 Event Propagation

Some additional details about events, propagation, and the browser's default action.

- By default, events propagate from the target node upwards until the root node is reached (bubbling).
- Event handlers can stop propagation using the `event.stopPropagation` function.
- Event handlers can also stop the browser from performing the default action for an event by calling the `event.preventDefault` function

Example: Event Handler

```
main.addEventListener("click", function(event) {
  event.stopPropagation();
  event.preventDefault();

  // ...
});
```

8.9.7 Event Delegation

- Parent receives event instead of child (via bubbling)
- Children can change without messing with event registration
- Fewer handlers registered, fewer callbacks
- Relies on some event object properties:
  - `event.target`: The element the event triggered for
  - `event.currentTarget`: Registered element (parent)

8.9.8 Event Handling: A Complete Example

```
node.addEventListener("click", function(event) {
  // `this' === Node the handler was registered on.
  console.log(this);

  // `event.target' === Node that triggered the event.
  console.log(event.target);

  // Add a CSS class:
  event.target.classList.add("was-clicked");

  // You can stop default browser behavior:
  event.preventDefault();
});
```

8.9.9 Exercise: Simple User Interaction

1. Open the following files in your text editor:
   - `src/www/js/events/events.js`
   - `src/www/js/events/index.html` (read only!)
2. Open the `index.html` file in your web browser.
3. Complete the exercise.

8.9.10 Event Loop Warnings

- Avoid blocking functions (e.g., `alert`, `confirm`)
- For long tasks use eteration or web workers
- Eteration: Break work up using `setTimeout(0)`

8.9.11 Event "Debouncing"

- Respond to events in intervals instead of in real-time
- Reuse a timeout object to process events in the future

```
var input   = document.getElementById("search"),
    output  = document.getElementById("output"),
    timeout = null;

var updateSearchResults = function() {
  output.textContent = input.value;
};

input.addEventListener("keydown", function(e) {
  if (timeout) clearTimeout(timeout);
  timeout = setTimeout(updateSearchResults, 100);
});
```

Chapter 9

Asynchronous JavaScript and XML

9.1 Introduction

9.1.1 Ajax Basics

- Asynchronous JavaScript and XML
- API for making HTTP requests
- Handled by the `XMLHttpRequest` object
- Introduced by Microsoft in the late 1990s
- Why use it? Non-blocking server interaction!
- Limited by the same-origin policy

9.1.2 Ajax: Step by Step

1. JavaScript asks for an HTTP connection
2. Browser makes a request in the background
3. Server responds in XML/JSON/HTML
4. Browser parses and processes response
5. Browser invokes JavaScript callback

9.2 The XHR API

9.2.1 Sending a Request, Basic Overview

```
var req = new XMLHttpRequest();

// Attach event listener...

req.open("GET", "/example/foo.json");
req.send(null);
```

9.2.2 Knowing When the Request Is Complete

```
var req = new XMLHttpRequest();

req.addEventListener("load", function(e) {
  if (req.status == 200) {
    console.log(req.responseText);
  }
});
```

9.3 Payload Formats

9.3.1 Popular Data Formats for Ajax

- HTML: Easiest to deal with
- XML: Pure data, but verbose
- JSON: Pure data, very popular

9.3.2 Ajax with HTML

- Easiest way to go
- Just directly insert the response into the DOM
- Scripts will **not** run

9.3.3 Ajax with XML

More work to extract data from XML:

```
request.addEventListener("load", function() {
  if (request.status >= 200 && request.status < 300) {
    var data = request.responseXML;
    var messages = data.getElementsByTagName("message");

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

9.3.4 What is JavaScript Object Notation (JSON)?

- Used as a data storage and communications format
- Very similar to object literals, with a few restrictions
  - Property names must be in double quotes
  - No function definitions, function calls, or variables
- Built-in methods:
  - `JSON.stringify(object);`
  - `JSON.parse(string);`
- Example:

```
{
  "messages": [
    {"text": "Hello", "priority": 1},
    {"text": "Bye",   "priority": 2}
  ],
  "sender": "Lazy automated system"
}
```

9.3.5 Ajax with JSON

- Sent and received as a string
- Needs to be serialized and de-serialized:

```
req.send(JSON.stringify(object));

// ...

var data = JSON.parse(req.responseText);
```

9.4 Tips and Tricks

9.4.1 Should You Use the XHR API?

- It is best to use an abstraction for `XMLHttpRequest`
- They usually come with better:
  - `status` and `statusCode` handling
  - Error handling
  - Callback registration
  - Variations in browser implementations
  - Additional event handling (progress, load, error, etc.)
- So, use a library like jQuery

9.5 Putting It All Together

9.5.1 Exercise: Making Ajax Requests

1. Open the following files:
   - `src/www/js/artists/artists.js`
   - `src/www/js/artists/index.html` (read only!)
2. Open http://localhost:3000/js/artists/
3. Complete the exercise.

9.6 Restrictions and Getting Around Them

9.6.1 Same-origin Policy and Cross-origin Requests

- By default, Ajax requests must be made on the same domain
- Getting around the same-origin policy
  - A proxy on the server
  - JSONP: JSON with Padding
  - Cross-origin Resource Sharing (CORS) (`>=` IE10)

Recommendation: Use CORS.

9.6.2 Introducing JSONP

- Browser doesn't enforce the same-origin policy for resources (images, CSS files, and JavaScript files)
- You can emulate an Ajax call to another domain that returns JSON by doing the following:
  1. Write a function that will receive the JSON as an argument
  2. Create a `<script>` element and set the `src` attribute to a remote domain, include the name of the function above in the query string.
  3. The remote server will return JavaScript (not JSON)
  4. The JavaScript will simply be a function call to the function you defined in step 1, with the requested JSON data as its only argument.

9.6.3 Example: JSONP

1. Define your function:

   ```
   function myCallback (someObject) { /* ... */ }
   ```

2. Create the script tag:

   ```
   <script src="http://server/api?jsonp=myCallback">
   </script>
   ```

3. The browser fetches the URL, which contains:

   ```
   myCallback({answer: "Windmill"});
   ```

4. Your function is called with the requested data

JavaScript Resources

JavaScript Documentation

- Mozilla Developer Network

Books on JavaScript

- JavaScript: The Good Parts
  - By: Douglas Crockford
  - Great (re-)introduction to the language and common pitfalls
- "You Don't Know JS" (book series)
  - By: Kyle Simpson
  - Look at JavaScript in a new light
  - https://github.com/getify/You-Dont-Know-JS
- Learning JavaScript Design Patterns
  - By: Addy Osmani
  - Through book about design patters in JavaScript
  - Exercises and Answers

Training Videos from Pluralsight

Beginner to Intermediate

- Basics of Programming with JavaScript
- JavaScript Fundamentals
- Building a JavaScript Development Environment
- JavaScript: From Fundamentals to Functional JS

Intermediate to Advanced

- Object-oriented Programming in JavaScript
- Reasoning About Asynchronous JavaScript
- Advanced JavaScript
- TypeScript Fundamentals
- Angular 2: Getting Started

Libraries

- Testing: [Jasmine][], [JSPec][], [Sinon][], and [Chai][]

Compatibility Tables

- ES6 Status By kangax