JAVASCRIPT FUNDAMENTALS

FLAVIO COPES

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Preface

Welcome!

Thank you for getting this ebook.

I hope its content will help you achieve what you want.

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Introduction to JavaScript

JavaScript is one of the most popular programming languages in the world, and now widely used also outside of the browser. The rise of Node.js in the last few years unlocked backend development, once the domain of Java, Ruby, Python and PHP and more traditional server-side languages. Learn all about it!

Introduction

JavaScript is one of the most popular programming languages in the world.

Created in 20 years ago, it's gone a very long way since its humble beginnings.

Being the first - and the only - scripting language that was supported natively by web browsers, it simply sticked.

In the beginnings, it was not nearly powerful as it is today, and it was mainly used for fancy animations and the marvel known at the time as DHTML.

With the growing needs that the web platform demands, JavaScript *had* the responsibility to grow as well, to accommodate the needs of one of the most widely used ecosystem of the world.

Many things were introduced in the platform, with browser APIs, but the language grew quite a lot as well.

JavaScript is now widely used also outside of the browser. The rise of Node.js in the last few years unlocked backend development, once the domain of Java, Ruby, Python and PHP and more traditional server-side languages.

JavaScript is now also the language powering databases and many more applications, and it's even possible to develop embedded applications, mobile apps, TV sets apps and much more. What started as a tiny language inside the browser is now the most popular language in the world.

Basic definition of JavaScript

JavaScript is a programming language that is:

- **high level**: it provides abstractions that allow you to ignore the details of the machine where it's running on. It manages memory automatically with a garbage collector, so you can focus on the code instead of managing memory locations, and provides many constructs which allow you to deal with highly powerful variables and objects.
- **dynamic**: opposed to static programming languages, a dynamic language executes at runtime many of the things that a static language does at compile time. This has pros and cons, and it gives us powerful features like dynamic typing, late binding, reflection, functional programming, object runtime alteration, closures and much more.
- **dynamically typed**: a variable does not enforce a type. You can reassign any type to a variable, for example assigning an integer to a variable that holds a string.
- **weakly typed**: as opposed to strong typing, weakly (or loosely) typed languages do not enforce the type of an object, allowing more flexibility but denying us type safety and type checking (something that TypeScript and Flow aim to improve)
- **interpreted**: it's commonly known as an interpreted language, which means that it does not need a compilation stage before a program can run, as opposed to C, Java or Go for example. In practice, browsers do compile JavaScript before executing it, for performance reasons, but this is transparent to you: there is no additional step involved.
- **multi-paradigm**: the language does not enforce any particular programming paradigm, unlike Java for example which forces the use of object oriented programming, or C that forces imperative programming. You can write JavaScript using an object-oriented paradigm, using prototypes and the new (as of ES6) classes syntax. You can write JavaScript in functional programming style, with its first class functions, or even in an imperative style (C-like).

In case you're wondering, *JavaScript has nothing to do with Java*, it's a poor name choice but we have to live with it.

JavaScript versions

Let me introduce the term *ECMAScript* here. We have a complete guide dedicated to ECMAScript where you can dive into it more, but to start with, you just need to know that ECMAScript (also called **ES**) is the name of the JavaScript standard.

JavaScript is an implementation of that standard. That's why you'll hear about ES6, ES2015, ES2016, ES2017, ES2018 and so on.

For a very long time, the version of JavaScript that all browser ran was ECMAScript 3. Version 4 was cancelled due to feature creep (they were trying to add too many things at once), while ES5 was a huge version for JS.

ES2015, also called ES6, was huge as well.

Since then, the ones in charge decided to release one version per year, to avoid having too much time idle between releases, and have a faster feedback loop.

Currently the latest approved JavaScript version is ES2017.

ECMAScript

ECMAScript is the standard upon which JavaScript is based, and it's often abbreviated to ES. Discover everything about ECMAScript, and the last features added in ES6, 7, 8

Introduction

Whenever you read about JavaScript you'll inevitably see one of these terms:

- ES3

- ES5
- ES6
- ES7
- ES8
- ES2015
- ES2016
- ES2017
- ECMAScript 2017
- ECMAScript 2016
- ECMAScript 2015

What do they mean?

They are all referring to a **standard**, called ECMAScript.

ECMAScript is **the standard upon which JavaScript is based**, and it's often abbreviated to **ES**.

Beside JavaScript, other languages implement(ed) ECMAScript, including:

- *ActionScript* (the Flash scripting language), which is losing popularity since Flash will be officially discontinued in 2020
- *JScript* (the Microsoft scripting dialect), since at the time JavaScript was supported only by Netscape and the browser wars were at their peak, Microsoft had to build its own version for Internet Explorer

but of course JavaScript is the **most popular** and widely used implementation of ES.

Why this weird name? `Ecma International` is a Swiss standards association who is in charge of defining international standards.

When JavaScript was created, it was presented by Netscape and Sun Microsystems to Ecma and they gave it the name ECMA-262 alias **ECMAScript**.

This press release by Netscape and Sun Microsystems (the maker of Java) might help figure out the name choice, which might include legal and branding issues by Microsoft which was in the committee, according to Wikipedia.

After IE9, Microsoft stopped stopped branding its ES support in browsers as JScript and started calling it JavaScript (at least, I could not find references to it any more)

So as of 201x, the only popular language supporting the ECMAScript spec is JavaScript.

Current ECMAScript version

The current ECMAScript version is **ES2017**, AKA **ES8**

It was released in June 2017.

When is the next version coming out?

Historically JavaScript editions have been standardized in June, so we can expect **ECMAScript 2018** (named **ES2018** or **ES9**) to be released in June 2018, but this is just speculation.

What is TC39

TC39 is the committee that evolves JavaScript.

The members of TC39 are companies involved in JavaScript and browser vendors, including Mozilla, Google, Facebook, Apple, Microsoft, Intel, PayPal, SalesForce and others.

Every standard version proposal must go through various stages, which are explained here.

ES Versions

I found it puzzling why sometimes an ES version is referenced by edition number and sometimes by year, and I am confused by the year by chance being -1 on the number, which adds to the general confusion around JS/ES

Before ES2015, ECMAScript specifications were commonly called by their edition. So ES5 is the official name for the ECMAScript specification update published in 2009.

Why does this happen? During the process that led to ES2015, the name was changed from ES6 to ES2015, but since this was done late, people still referenced it as ES6, and the community has not left the edition naming behind - *the world is still calling ES releases by edition number*.

This table should clear things a bit:

Edition	Official name	Date published
ES8	ES2017	June 2017
ES7	ES2016	June 2016
ES6	ES2015	June 2015
ES5.1	ES5.1	June 2011
ES5	ES5	December 2009
ES4	ES4	Abandoned
ES3	ES3	December 1999
ES2	ES2	June 1998

ES1	ES1	June 1997

ES Next

ES.Next is a name that always indicates the next version of JavaScript.

So at the time of writing, ES8 has been released, and **ES.Next is ES9**

ES2015 aka ES6

ECMAScript 2015, also known as ES6, is a fundamental version of the ECMAScript standard.

Published 4 years after the latest standard revision, ECMAScript 5.1, it also marked the switch from edition number to year number.

So **it should not be named as ES6** (although everyone calls it as such) but ES2015 instead.

> ES5 was 10 years in the making, from 1999 to 2009, and as such it was also a fundamental and very important revision of the language, but now much time has passed that it's not worth discussing how pre-ES5 code worked.

Since this long time passed between ES5.1 and ES6, the release is full of important new features and major changes in suggested best practices in developing JavaScript programs. To understand how fundamental ES2015 is, just keep in mind that with this version, the specification document went from 250 pages to ~600.

The most important changes in ES2015 include

- Arrow functions
- Promises
- Generators
- `let` and `const`
- Classes
- Modules
- Multiline strings
- Template literals
- Default parameters
- The spread operator
- Destructuring assignments
- Enhanced object literals
- The for..of loop
- Map and Set

Each of them has a dedicated section in this article.

Arrow Functions

Arrow functions since their introduction changed how most JavaScript code looks (and works).

Visually, it's a simple and welcome change, from:

```
const foo = function foo() {
  //...
}
```

to

```
const foo = () => {
  //...
}
```

And if the function body is a one-liner, just:

```
const foo = () => doSomething()
```

Also, if you have a single parameter, you could write:

```
const foo = param => doSomething(param)
```

This is not a breaking change, regular `function`s will continue to work just as before.

A new `this` scope

The `this` scope with arrow functions is inherited from the context.

With regular `function`s `this` always refers to the nearest function, while with arrow functions this problem is removed, and you won't need to write `var that = this` ever again.

Promises

Promises (check the full guide to promises) allow us to eliminate the famous "callback hell", although they introduce a bit more complexity (which has been solved in ES2017 with `async`, a higher level construct).

Promises have been used by JavaScript developers well before ES2015, with many different libraries implementations (e.g. jQuery, q, deferred.js, vow...), and the standard put a common ground across differences.

By using promises you can rewrite this code

```
setTimeout(function() {
  console.log('I promised to run after 1s')
  setTimeout(function() {
    console.log('I promised to run after 2s')
  }, 1000)
}, 1000)
```

as

```
const wait = () => new Promise((resolve, reject) => {
  setTimeout(resolve, 1000)
})

wait().then(() => {
  console.log('I promised to run after 1s')
  return wait()
})
.then(() => console.log('I promised to run after 2s'))
```

Generators

Generators are a special kind of function with the ability to pause itself, and resume later, allowing other code to run in the meantime.

The code decides that it has to wait, so it lets other code "in the queue" to run, and keeps the right to resume its operations "when the thing it's waiting for" is done.

All this is done with a single, simple keyword: `yield`. When a generator contains that keyword, the execution is halted.

A generator can contain many `yield` keywords, thus halting itself multiple times, and it's identified by the `*function` keyword, which is not to be confused with the pointer dereference operator used in lower level programming languages such as C, C++ or Go.

Generators enable whole new paradigms of programming in JavaScript, allowing:

- 2-way communication while a generator is running
- long-lived while loops which do not freeze your program

Here is an example of a generator which explains how it all works.

```
function *calculator(input) {
    var doubleThat = 2 * (yield (input / 2))
    var another = yield (doubleThat)
    return (input * doubleThat * another)
}
```

We initialize it with

```
const calc = calculator(10)
```

Then we start the iterator on our generator:

```
calc.next()
```

This first iteration starts the iterator. The code returns this object:

```
{
  done: false
  value: 5
}
```

What happens is: the code runs the function, with `input = 10` as it was passed in the generator constructor. It runs until it reaches the `yield`, and returns the content of `yield`: `input / 2 = 5`. So we got a value of 5, and the indication that the iteration is not done (the function is just paused).

In the second iteration we pass the value `7`:

```
calc.next(7)
```

and what we got back is:

```
{
  done: false
  value: 14
}
```

`7` was placed as the value of `doubleThat`. Important: you might read like `input / 2` was the argument, but that's just the return value of the first iteration. We now skip that, and use the new input value, `7`, and multiply it by 2.

We then reach the second yield, and that returns `doubleThat`, so the returned value is `14`.

In the next, and last, iteration, we pass in 100

```
calc.next(100)
```

and in return we got

```
{
  done: true
  value: 14000
}
```

As the iteration is done (no more yield keywords found) and we just return `(input * doubleThat * another)` which amounts to `10 * 14 * 100`.

`let` and `const`

`var` is traditionally **function scoped**.

`let` is a new variable declaration which is **block scoped**.

This means that declaring `let` variables in a for loop, inside an if or in a plain block is not going to let that variable "escape" the block, while `var`s are hoisted up to the function definition.

`const` is just like `let`, but **immutable**.

In JavaScript moving forward, you'll see little to no `var` declarations any more, just `let` and `const`.

`const` in particular, maybe surprisingly, is **very widely used** nowadays with immutability being very popular.

Classes

Traditionally JavaScript is the only mainstream language with prototype-based inheritance. Programmers switching to JS from class-based language found it puzzling, but ES2015 introduced classes, which are just syntactic sugar over the inner working, but changed a lot how we build JavaScript programs.

Now inheritance is very easy and resembles other object-oriented programming languages:

```
class Person {
  constructor(name) {
    this.name = name
  }

  hello() {
    return 'Hello, I am ' + this.name + '.'
```

```
  }
}

class Actor extends Person {
  hello() {
    return super.hello() + ' I am an actor.'
  }
}

var tomCruise = new Actor('Tom Cruise')
tomCruise.hello()
```

(the above program prints "*Hello, I am Tom Cruise. I am an actor.*")

Classes do not have explicit class variable declarations, but you must initialize any variable in the constructor.

Constructor

Classes have a special method called `constructor` which is called when a class is initialized via `new`.

Super

The parent class can be referenced using `super()`.

Getters and setters

A getter for a property can be declared as

```
class Person {
  get fullName() {
    return `${this.firstName} ${this.lastName}`
  }
}
```

Setters are written in the same way:

```
class Person {
  set age(years) {
    this.theAge = years
  }
}
```

Modules

Before ES2015, there were at least 3 major modules competing standards, which fragmented the community:

- AMD
- RequireJS
- CommonJS

ES2015 standardized these into a common format.

Importing modules

Importing is done via the `import ... from ...` construct:

```
import * from 'mymodule'
import React from 'react'
import { React, Component } from 'react'
import React as MyLibrary from 'react'
```

Exporting modules

You can write modules and export anything to other modules using the `export` keyword:

```
export var foo = 2
export function bar() { /* ... */ }
```

Template Literals

Template literals are a new syntax to create strings:

```
const aString = `A string`
```

They provide a way to embed expressions into strings, effectively interpolating the values, by using the `${a_variable}` syntax:

```
const var = 'test'
const string = `something ${var}` //something test
```

You can perform more complex expressions as well:

```
const string = `something ${1 + 2 + 3}`
const string2 = `something ${foo() ? 'x' : 'y' }`
```

and strings can span over multiple lines:

```
const string3 = `Hey
this

string
is awesome!`
```

Compare how we used to do multiline strings pre-ES2015:

```
var str = 'One\n' +
'Two\n' +
'Three'
```

> See this post for an in-depth guide on template literals

Default parameters

Functions now support default parameters:

```
const foo = function(index = 0, testing = true) { /* ... */ }
foo()
```

The spread operator

You can expand an array, an object or a string using the spread operator `...`.

Let's start with an array example. Given

```
const a = [1, 2, 3]
```

you can create a new array using

```
const b = [...a, 4, 5, 6]
```

You can also create a copy of an array using

```
const c = [...a]
```

This works for objects as well. Clone an object with:

```
const newObj = { ...oldObj }
```

Using strings, the spread operator creates an array with each char in the string:

```
const hey = 'hey'
const arrayized = [...hey] // ['h', 'e', 'y']
```

This operator has some pretty useful applications. The most important one is the ability to use an array as function argument in a very simple way:

```
const f = (foo, bar) => {}
const a = [1, 2]
f(...a)
```

(in the past you could do this using `f.apply(null, a)` but that's not as nice and readable)

Destructuring assignments

Given an object, you can extract just some values and put them into named variables:

```
const person = {
  firstName: 'Tom',
  lastName: 'Cruise',
  actor: true,
  age: 54, //made up
}

const {firstName: name, age} = person
```

`name` and `age` contain the desired values.

The syntax also works on arrays:

```
const a = [1,2,3,4,5]
[first, second, , , fifth] = a
```

Enhanced Object Literals

In ES2015 Object Literals gained superpowers.

Simpler syntax to include variables

Instead of doing

```
const something = 'y'
const x = {
  something: something
}
```

you can do

```
const something = 'y'
const x = {
  something
}
```

Prototype

A prototype can be specified with

```
const anObject = { y: 'y' }
const x = {
  __proto__: anObject
}
```

super()

```
const anObject = { y: 'y', test: () => 'zoo' }
const x = {
  __proto__: anObject,
  test() {
    return super.test() + 'x'
  }
}
x.test() //zoox
```

Dynamic properties

```
const x = {
  ['a' + '_' + 'b']: 'z'
}
x.a_b //z
```

For-of loop

ES5 back in 2009 introduced `forEach()` loops. While nice, they offered no way to break, like `for` loops always did.

ES2015 introduced the **`for-of` loop**, which combines the conciseness of `forEach` with the ability to break:

```
//iterate over the value
for (const v of ['a', 'b', 'c']) {
  console.log(v);
```

```
}

//get the index as well, using `entries()`
for (const [i, v] of ['a', 'b', 'c'].entries()) {
  console.log(i, v);
}
```

Map and Set

Map and **Set** (and their respective garbage collected **WeakMap** and **WeakSet**) are the official implementations of two very popular data structures.

ES2016 aka ES7

ES7, officially known as ECMAScript 2016, was finalized in June 2016.

Compared to ES6, ES7 is a tiny release for JavaScript, containing just two features:

- Array.prototype.includes
- Exponentiation Operator

Array.prototype.includes()

This feature introduces a more readable syntax for checking if an array contains an element.

With ES6 and lower, to check if an array contained an element you had to use `indexOf`, which checks the index in the array, and returns `-1` if the element is not there.

Since `-1` is evaluated as a true value, you could **not** do for example

```
if (![1,2].indexOf(3)) {
  console.log('Not found')
}
```

With this feature introduced in ES7 we can do

```
if (![1,2].includes(3)) {
  console.log('Not found')
}
```

Exponentiation Operator

The exponentiation operator `**` is the equivalent of `Math.pow()`, but brought into the language instead of being a library function.

```
Math.pow(4, 2) == 4 ** 2
```

This feature is a nice addition for math intensive JS applications.

The `**` operator is standardized across many languages including Python, Ruby, MATLAB, Lua, Perl and many others.

ES2017 aka ES8

ECMAScript 2017, edition 8 of the ECMA-262 Standard (also commonly called **ES2017** or **ES8**), was finalized in June 2017.

Compared to ES6, ES8 is a tiny release for JavaScript, but still it introduces very useful features:

- String padding
- Object.values
- Object.entries
- Object.getOwnPropertyDescriptors()
- Trailing commas in function parameter lists and calls
- Async functions
- Shared memory and atomics

String padding

The purpose of string padding is to **add characters to a string**, so it **reaches a specific length**.

ES2017 introduces two `String` methods: `padStart()` and `padEnd()`.

```
padStart(targetLength [, padString])
padEnd(targetLength [, padString])
```

Sample usage:

padStart()	
'test'.padStart(4)	'test'
'test'.padStart(5)	' test'
'test'.padStart(8)	' test'
'test'.padStart(8, 'abcd')	'abcdtest'

padEnd()	
'test'.padEnd(4)	'test'
'test'.padEnd(5)	'test '
'test'.padEnd(8)	'test '
'test'.padEnd(8, 'abcd')	'testabcd'

Object.values()

This method returns an array containing all the object own property values.

Usage:

```
const person = { name: 'Fred', age: 87 }
Object.values(person) // ['Fred', 87]
```

`Object.values()` also works with arrays:

```
const people = ['Fred', 'Tony']
Object.values(people) // ['Fred', 'Tony']
```

Object.entries()

This method returns an array containing all the object own properties, as an array of `[key, value]` pairs.

Usage:

```
const person = { name: 'Fred', age: 87 }
Object.entries(person) // [['name', 'Fred'], ['age', 87]]
```

`Object.entries()` also works with arrays:

```
const people = ['Fred', 'Tony']
Object.entries(people) // [['0', 'Fred'], ['1', 'Tony']]
```

getOwnPropertyDescriptors()

This method returns all own (non-inherited) properties descriptors of an object.

Any object in JavaScript has a set of properties, and each of these properties has a descriptor.

A descriptor is a set of attributes of a property, and it's composed by a subset of the following:

- **value**: the value of the property
- **writable**: true the property can be changed
- **get**: a getter function for the property, called when the property is read
- **set**: a setter function for the property, called when the property is set to a value
- **configurable**: if false, the property cannot be removed nor any attribute can be changed, except its value
- **enumerable**: true if the property is enumerable

`Object.getOwnPropertyDescriptors(obj)` accepts and object, and returns an object with the set of descriptors.

In what way is this useful?

ES2015 gave us `Object.assign()`, which copies all enumerable own properties from one or more objects, and return a new object.

However there is a problem with that, because it does not correctly copies properties with non-default attributes.

If an object for example has just a setter, it's not correctly copied to a new object, using `Object.assign()`.

For example with

```
const person1 = {
    set name(newName) {
        console.log(newName)
    }
}
```

This won't work:

```
const person2 = {}
Object.assign(person2, person1)
```

But this will work:

```
const person3 = {}
Object.defineProperties(person3,
  Object.getOwnPropertyDescriptors(person1))
```

As you can see with a simple console test:

```
person1.name = 'x'
"x"
```

```
person2.name = 'x'

person3.name = 'x'
"x"
```

`person2` misses the setter, it was not copied over.

The same limitation goes for shallow cloning objects with **Object.create()**.

Trailing commas

This feature allows to have trailing commas in function declarations, and in functions calls:

```
const doSomething = (var1, var2,) => {
  //...
}

doSomething('test2', 'test2',)
```

This change will encourage developers to stop the ugly "comma at the start of the line" habit.

Async functions

> Check the dedicated post about async/await

ES2017 introduced the concept of **async functions**, and it's the most important change introduced in this ECMAScript edition.

Async functions are a combination of promises and generators to reduce the boilerplate around promises, and the "don't break the chain" limitation of chaining promises.

Why they are useful

It's a higher level abstraction over promises.

When Promises were introduced in ES2015, they were meant to solve a problem with asynchronous code, and they did, but over the 2 years that separated ES2015 and ES2017, it was clear that *promises could not be the final solution*. Promises were introduced to solve the famous *callback hell* problem, but they introduced complexity on their own, and syntax complexity. They were good primitives around which a better syntax could be exposed to the developers: enter **async functions**.

A quick example

Code making use of asynchronous functions can be written as

```
function doSomethingAsync() {
    return new Promise((resolve) => {
        setTimeout(() => resolve('I did something'), 3000)
    })
}

async function doSomething() {
    console.log(await doSomethingAsync())
}

console.log('Before')
doSomething()
console.log('After')
```

The above code will print the following to the browser console:

```
Before
After
I did something //after 3s
```

Multiple async functions in series

Async functions can be chained very easily, and the syntax is much more readable than with plain promises:

```
function promiseToDoSomething() {
    return new Promise((resolve)=>{
        setTimeout(() => resolve('I did something'), 10000)
    })
}

async function watchOverSomeoneDoingSomething() {
    const something = await promiseToDoSomething()
    return something + ' and I watched'
}

async function watchOverSomeoneWatchingSomeoneDoingSomething() {
    const something = await watchOverSomeoneDoingSomething()
    return something + ' and I watched as well'
}

watchOverSomeoneWatchingSomeoneDoingSomething().then((res) => {
    console.log(res)
})
```

Shared Memory and Atomics

WebWorkers are used to create multithreaded programs in the browser.

They offer a messaging protocol via events. Since ES2017, you can create a shared memory array between web workers and their creator, using a `SharedArrayBuffer`.

Since it's unknown how much time writing to a shared memory portion takes to propagate, **Atomics** are a way to enforce that when reading a value, any kind of writing operation is completed.

Any more detail on this can be found in the spec proposal, which has since been implemented.

Lexical Structure

A deep dive into the building blocks of JavaScript: unicode, semicolons, white space, case sensitivity, comments, literals, identifiers and reserved words

Unicode

JavaScript is written in Unicode. This means you can use Emojis as variable names, but more importantly, you can write identifiers in any language, for example Japanese or Chinese, with some rules.

Semicolons

JavaScript has a very C-like syntax, and you might see lots of code samples that feature semicolons at the end of each line.

Semicolons aren't mandatory, and JavaScript does not have any problem in code that does not use them, and lately many developers, especially those coming from languages that do not have semicolons, started avoiding using them.

You just need to avoid doing strange things like typing statements on multiple lines

```
return
variable
```

or starting a line with parentheses (`[` or `(`) and you'll be safe 99.9% of the times (and your linter will warn you).

It goes to personal preference, and lately I have decided to **never add useless semicolons**, so on this site you'll never see them.

White space

JavaScript does not consider white space meaningful. Spaces and line breaks can be added in any fashion you might like, even though this is *in theory*.

In practice, you will most likely keep a well defined style and adhere to what people commonly use, and enforce this using a linter or a style tool such as *Prettier*.

For example I like to always 2 characters to indent.

Case sensitive

JavaScript is case sensitive. A variable named `something` is different from `Something`.

The same goes for any identifier.

Comments

You can use two kind of comments in JavaScript:

```
/* */

//
```

The first can span over multiple lines and needs to be closed.

The second comments everything that's on its right, on the current line.

Literals and Identifiers

We define as **literal** a value that is written in the source code, for example a number, a string, a boolean or also more advanced constructs, like Object Literals or Array Literals:

```
5
'Test'
true
['a', 'b']
{color: 'red', shape: 'Rectangle'}
```

An **identifier** is a sequence of characters that can be used to identify a variable, a function, an object. It can start with a letter, the dollar sign `$` or an underscore `_`, and it can contain digits. Using Unicode, a letter can be any allowed char, for example an emoji .

```
Test
test
TEST
_test
Test1
$test
```

The dollar sign is commonly used to reference DOM elements.

Reserved words

You can't use as identifiers any of the following words:

```
break
do
instanceof
typeof
case
else
new
var
catch
finally
return
void
continue
for
switch
while
debugger
function
this
with
default
if
throw
delete
in
try
class
enum
extends
super
const
export
import
implements
let
private
public
interface
package
```

```
protected
static
yield
```

because they are reserved by the language.

Variables

A variable is a literal assigned to an identifier, so you can reference and use it later in the program. Learn how to declare one with JavaScript

Introduction to JavaScript Variables

A variable is a literal assigned to an identifier, so you can reference and use it later in the program.

Variables in JavaScript do not have any type attached. Once you assign a specific literal type to a variable, you can later reassign the variable to host any other type, without type errors or any issue.

This is why JavaScript is sometimes referenced as "untyped".

A variable must be declared before you can use it. There are 3 ways to do it, using `var`, `let` or `const`, and those 3 ways differ in how you can interact with the variable later on.

Using `var`

Until ES2015, `var` was the only construct available for defining variables.

```
var a = 0
```

If you forget to add `var` you will be assigning a value to an undeclared variable, and the results might vary.

In modern environments, with strict mode enabled, you will get an error. In older environments (or with strict mode disabled) this will simply initialize the variable and assign it to the global object.

If you don't initialize the variable when you declare it, it will have the `undefined` value until you assign a value to it.

```
var a //typeof a === 'undefined'
```

You can redeclare the variable many times, overriding it:

```
var a = 1
var a = 2
```

You can also declare multiple variables at once in the same statement:

```
var a = 1, b = 2
```

The **scope** is the portion of code where the variable is visible.

A variable initialized with `var` outside of any function is assigned to the global object, has a global scope and is visible everywhere. A variable initialized with `var` inside a function is assigned to that function, it's local and is visible only inside it, just like a function parameter.

Any variable defined into a function with the same name of a global variable takes precedence over the global variable, shadowing it.

It's important to understand that a block (identified by a pair of curly braces) does not define a new scope. A new scope is only created when a function is created, because `var` has not block scope, but function scope.

Inside a function, any variable defined in it is visible throughout all the function code, even if the variable is declared at the end of the function it can still be referenced in the beginning, because JavaScript before executing the code actually *moves all variables on top* (something that is called **hoisting**). To avoid confusion, always declare variables at the beginning of a function.

Using `let`

`let` is a new feature introduced in ES2015 and it's essentially a block scoped version of `var`. Its scope is limited to the block, statement or expression where it's defined, and all the contained inner blocks.

Modern JavaScript developers might choose to only use `let` and completely discard the use of `var`.

> If `let` seems an obscure term, just read `let color = 'red'` as *let the color be red* and all has much more sense

Defining `let` outside of any function - contrary to `var` - does not create a global variable.

Using `const`

Variables declared with `var` or `let` can be changed later on in the program, and reassigned. A once a `const` is initialized, its value can never be changed again, and it can't be reassigned to a different value.

```
const a = 'test'
```

We can't assign a different literal to the `a` const. We can however mutate `a` if it's an object that provides methods that mutate its contents.

`const` does not provide immutability, just makes sure that the reference can't be changed.

`const` has block scope, same as `let`.

Modern JavaScript developers might choose to always use `const` for variables that don't need to be reassigned later in the program.

> Why? Because we should always use the simplest construct available to avoid making errors down the road.

Types

You might sometimes read that JS is untyped, but that's incorrect. It's true that you can assign all sorts of different types to a variable, but JavaScript has types. In particular, it provides primitive types, and object types.

Primitive types

Primitive types are

- Numbers
- Strings
- Booleans

And two special types:

- null
- undefined

Let's see them in details in the next sections.

Numbers

Internally, JavaScript has just one type for numbers: every number is a float.

A numeric literal is a number represented in the source code, amd depending on how it's written, it can be an integer literal or a floating point literal.

Integers:

```
10
5354576767321
0xCC //hex
```

Floats:

```
3.14
.1234
5.2e4 //5.2 * 10^4
```

Strings

A string type is a sequence of characters. It's defined in the source code as a string literal, which is enclosed in quotes or double quotes

```
'A string'
"Another string"
```

Strings can span across multiple lines by using the backslash

```
"A \
string"
```

A string can contain escape sequences that can be interpreted when the string is printed, like \n to create a new line. The backslash is also useful when you need to enter for example a quote in a string enclosed in quotes, to prevent the char to be interpreted as a closing quote:

```
'I\'m a developer'
```

Strings can be joined using the + operator:

```
"A " + "string"
```

Template strings

Introduced in ES2015, template strings are string literals that allow a more powerful way to define strings.

```
`a string`
```

You can perform string substitution, embedding the result of any JS expression:

```
`a string with ${something}`
`a string with ${something+somethingElse}`
`a string with ${obj.something()}`
```

You can have multiline strings easily:

```
`a string
with
${something}`
```

Booleans

JavaScript defines two reserved words for booleans: true and false. Many comparision operations `==` `===` `<` `>` (and so on) return either one or the other.

`if` , `while` statements and other control structures use booleans to determine the flow of the program.

They don't just accept true or false, but also accept **truthy** and **falsy** values.

Falsy values, values **interpreted as false**, are

```
0
-0
NaN
undefined
null
'' //empty string
```

All the rest is considered a **truthy value**.

null

`null` is a special value that indicates the absence of a value.

It's a common concept in other languages as well, can be known as `nil` or `None` in Python for example.

undefined

`undefined` indicates that a variable has not been initialized and the value is absent.

It's commonly returned by functions with no `return` value. When a function accepts a parameter but that's not set by the caller, it's undefined.

To detect if a value is `undefined` , you use the construct:

```
typeof variable === 'undefined'
```

Object types

Anything that's not a primitive type is an object type.

Functions, arrays and what we call objects are object types. They are special on their own, but they inherit many properties of objects, like having properties and also having methods that can act on those properties.

Expressions

Expressions are units of code that can be evaluated and resolve to a value. Expressions in JS can be divided in categories.

- Arithmetic expressions
- String expressions
- Primary expressions
- Array and object initializers expressions
- Logical expressions
- Left-hand-side expressions
- Property access expressions
- Object creation expressions
- Function definition expressions
- Invocation expressions

Arithmetic expressions

Under this category go all expressions that evaluate to a number:

```
1 / 2
i++
i -= 2
i * 2
```

String expressions

Expressions that evaluate to a string:

```
'A ' + 'string'
'A ' += 'string'
```

Primary expressions

Under this category go variable references, literals and constants:

```
2
0.02
'something'
```

```
true
false
this //the current object
undefined
i //where i is a variable or a constant
```

but also some language keywords:

```
function
class
function* //the generator function
yield //the generator pauser/resumer
yield* //delegate to another generator or iterator
async function* //async function expression
await //async function pause/resume/wait for completion
/pattern/i //regex
() // grouping
```

Array and object initializers expressions

```
[] //array literal
{} //object literal
[1,2,3]
{a: 1, b: 2}
{a: {b: 1}}
```

Logical expressions

Logical expressions make use of logical operators and resolve to a boolean value:

```
a && b
a || b
!a
```

Left-hand-side expressions

```
new //create an instance of a constructor
super //calls the parent constructor
...obj //expression using the spread operator
```

Property access expressions

```
object.property //reference a property (or method) of an object
object[property]
object['property']
```

Object creation expressions

```
new object()
new a(1)
new MyRectangle('name', 2, {a: 4})
```

Function definition expressions

```
function() {}
function(a, b) { return a * b }
(a, b) => a * b
a => a * 2
() => { return 2 }
```

Invocation expressions

The syntax for calling a function or method

```
a.x(2)
window.resize()
```

Prototypal inheritance

JavaScript is quite unique in the popular programming languages landscape because of its usage of prototypal inheritance. Let's find out what that means

JavaScript is quite unique in the popular programming languages landscape because of its usage of prototypal inheritance.

While most object-oriented languages use a class-based inheritance model, JavaScript is based on the prototype inheritance model.

What does this mean?

Every single JavaScript object has a property, called `prototype`, which points to a different object.

This different object is the **object prototype**.

Our object uses that object prototype to inherit properties and methods.

Say you have an object created using the object literal syntax:

```
const car = {}
```

or one created with the `new Object` syntax:

```
const car = new Object()
```

in any case, the prototype of `car` is `Object`:

If you initialize an array, which is an object:

```
const list = []
//or
const list = new Array()
```

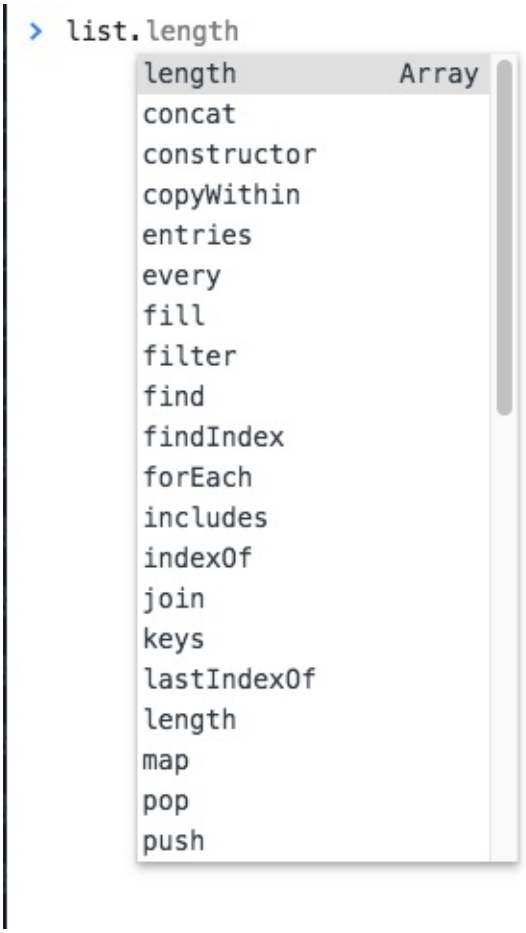
the prototype is `Array`.

You can verify this by checking the `__proto__` getter:

```
car.__proto__ == Object.prototype //true
car.__proto__ == new Object().__proto__ //true
list.__proto__ == Object.prototype //false
list.__proto__ == Array.prototype //true
list.__proto__ == new Array().__proto__ //true
```

> I use the `__proto__` property here, which is non-standard but widely implemented in browsers. A more reliable way to get a prototype is to use `Object.getPrototypeOf(new Object())`

All the properties and methods of the prototype are available to the object that has that prototype:



`Object.prototype` is the base prototype of all the objects:

```
Array.prototype.__proto__ == Object.prototype
```

If you wonder what's the prototype of the Object.prototype, there is no prototype. It's a special snowflake .

The above example you saw is an example of the **prototype chain** at work.

I can make an object that extends Array and any object I instantiate using it, will have Array and Object in its prototype chain and inherit properties and methods from all the ancestors.

In addition to using the `new` operator to create an object, or using the literals syntax for objects and arrays, you can instantiate an object using `Object.create()` .

The first argument passed is the object used as prototype:

```
const car = Object.create({})
const list = Object.create(Array)
```

You can check the prototype of an object using the `isPrototypeOf()` method:

```
Array.isPrototypeOf(list) //true
```

Pay attention because you can instantiate an array using

```
const list = Object.create(Array.prototype)
```

and in this case `Array.isPrototypeOf(list)` is false, while `Array.prototype.isPrototypeOf(list)` is true.

Classes

In 2015 the ECMAScript 6 (ES6) standard introduced classes. Learn all about them

In 2015 the ECMAScript 6 (ES6) standard introduced classes.

Before that, JavaScript only had a quite unique way to implement inheritance. Its prototypal inheritance, while in my opinion great, was different from any other popular programming language.

People coming from Java or Python or other languages had a hard time understanding the intricacies of prototypal inheritance, so the ECMAScript committee decided to introduce a syntactic sugar on top of them, and resemble how classes-based inheritance works in other popular implementations.

This is important: JavaScript under the hoods is still the same, and you can access an object prototype in the usual way.

A class definition

This is how a class looks.

```
class Person {
  constructor(name) {
    this.name = name
  }

  hello() {
    return 'Hello, I am ' + this.name + '.'
  }
}
```

A class has an identifier, which we can use to create new objects using `new ClassIdentifier()`.

When the object is initialized, the `constructor` method is called, with any parameters passed.

A class also has as many methods as it needs. In this case `hello` is a method and can be called on all objects derived from this class:

```
const flavio = new Person('Flavio')
flavio.hello()
```

Classes inheritance

A class can extend another class, and objects initialized using that class inherit all the methods of both classes.

If the inherited class has a method with the same name as one of the classes higher in the hierarchy, the closest method takes precedence:

```
class Programmer extends Person {
  hello() {
    return super.hello() + ' I am a programmer.'
  }
}

const flavio = new Programmer('Flavio')
flavio.hello()
```

(the above program prints "*Hello, I am Flavio. I am a programmer.*")

Classes do not have explicit class variable declarations, but you must initialize any variable in the constructor.

Inside a class, you can reference the parent class calling `super()`.

Static methods

Normally methods are defined on the instance, not on the class.

Static methods are executed on the class instead:

```
class Person {
  static genericHello() {
    return 'Hello'
  }
}

Person.genericHello() //Hello
```

Private methods

JavaScript does not have a built-in way to define private or protected methods.

There are workarounds, but I won't describe them here.

Getters and setters

You can add methods prefixed with `get` or `set` to create a getter and setter, which are two different pieces of code that are execute based on what you are doing: accessing the variable, or modifying its value.

```
class Person {
  constructor(name) {
    this.name = name
  }

  set name(value) {
    this.name = value
  }

  get name() {
    return this.name
  }
}
```

If you only have a getter, the property cannot be set, and any attempt at doing so will be ignored:

```
class Person {
  constructor(name) {
    this.name = name
  }

  get name() {
    return this.name
  }
}
```

If you only have a setter, you can change the value but not access it from the outside:

```
class Person {
  constructor(name) {
    this.name = name
  }

  set name(value) {
    this.name = value
  }
}
```

Exceptions

When the code runs into an unexpected problem, the JavaScript idiomatic way to handle this situation is through exceptions

When the code runs into an unexpected problem, the JavaScript idiomatic way to handle this situation is through exceptions.

Creating exceptions

An exception is created using the `throw` keyword:

```
throw value
```

where `value` can be any JavaScript value including a string, a number or an object.

As soon as JavaScript executes this line, the normal program flow is halted and the control is held back to the nearest **exception handler**.

Handling exceptions

An exception handler is a `try` / `catch` statement.

Any exception raised in the lines of code included in the `try` block is handled in the corresponding `catch` block:

```
try {
  //lines of code
} catch (e) {

}
```

`e` in this example is the exception value.

You can add multiple handlers, that can catch

`finally`

To complete this statement JavaScript has another statement called `finally`, which contains code that is executed regardless of the program flow, if the exception was handled or not, if there was an exception or if there wasn't:

```
try {
  //lines of code
} catch (e) {

} finally {

}
```

You can use `finally` without a `catch` block, to serve as a way to clean up any resource you might have opened in the `try` block, like files or network requests:

```
try {
  //lines of code
} finally {

}
```

Nested `try` blocks

`try` blocks can be nested, and an exception is always handled in the nearest catch block:

```
try {
  //lines of code

  try {
    //other lines of code
  } finally {
    //other lines of code
  }

} catch (e) {

}
```

If an exception is raised in the inner `try`, it's handled in the outer `catch` block.

Semicolons

JavaScript semicolons are optional. I personally like avoiding using semicolons in my code, but many people prefer them.

Semicolons in JavaScript divide the community. Some prefer to use them always, no matter what. Others like to avoid them.

After using semicolons for years, in the fall of 2017 I decided to try avoiding them as needed, and I did set up Prettier to automatically remove semicolons from my code, unless there is a particular code construct that requires them.

Now I find it natural to avoid semicolons, I think the code looks better and it's cleaner to read.

This is all possible because JavaScript does not strictly require semicolons. When there is a place where a semicolon was needed, it adds it behind the scenes.

The process that does this is called **Automatic Semicolon Insertion**.

It's important to know the rules that power semicolons, to avoid writing code that will generate bugs because does not behave like you expect.

The rules of JavaScript Automatic Semicolon Insertion

The JavaScript parser will automatically add a semicolon when, during the parsing of the source code, it finds these particular situations:

1. when the next line starts with code that breaks the current one (code can spawn on multiple lines)
2. when the next line starts with a `}`, closing the current block
3. when the end of the source code file is reached
4. when there is a `return` statement on its own line
5. when there is a `break` statement on its own line
6. when there is a `throw` statement on its own line
7. when there is a `continue` statement on its own line

Examples of code that does not do what you think

Based on those rules, here are some examples.

Take this:

```
const hey = 'hey'
const you = 'hey'
const heyYou = hey + ' ' + you

['h', 'e', 'y'].forEach((letter) => console.log(letter))
```

You'll get the error `Uncaught TypeError: Cannot read property 'forEach' of undefined` because based on rule `1` JavaScript tries to interpret the code as

```
const hey = 'hey';
const you = 'hey';
const heyYou = hey + ' ' + you['h', 'e', 'y'].forEach((letter) => console.log(letter))
```

Such piece of code:

```
(1 + 2).toString()
```

prints `"3"`.

```
const a = 1
const b = 2
const c = a + b
(a + b).toString()
```

instead raises a `TypeError: b is not a function` exception, because JavaScript tries to interpret it as

```
const a = 1
const b = 2
const c = a + b(a + b).toString()
```

Another example based on rule 4:

```
(() => {
  return
  {
    color: 'white'
  }
})()
```

You'd expect the return value of this immediately-invoked function to be an object that contains the `color` property, but it's not. Instead, it's `undefined`, because JavaScript inserts a semicolon after `return`.

Instead you should put the opening bracket right after `return`:

```
(() => {
  return {
    color: 'white'
  }
})()
```

You'd think this code shows '0' in an alert:

```
1 + 1
-1 + 1 === 0 ? alert(0) : alert(2)
```

but it shows 2 instead, because JavaScript per rule 1 interprets it as:

```
1 + 1 -1 + 1 === 0 ? alert(0) : alert(2)
```

Conclusion

Be careful. Some people are very opinionated on semicolons. I don't care honestly, the tool gives us the option not to use it, so we can avoid semicolons.

I'm not suggesting anything, other than picking your own decision.

We just need to pay a bit of attention, even if most of the times those basic scenarios never show up in your code.

Pick some rules:

- be careful with `return` statements. If you return something, add it on the same line as the return (same for `break`, `throw`, `continue`)
- never start a line with parentheses, those might be concatenated with the previous line to form a function call, or array element reference

And ultimately, always test your code to make sure it does what you want

Quotes

An overview of the quotes allowed in JavaScript and their unique features

JavaScript allows you to use 3 types of quotes:

- single quotes
- double quotes
- backticks

The first 2 are essentially the same:

```
const test = 'test'
const bike = "bike"
```

There's little to no difference in using one or the other. The only difference lies in having to escape the quote character you use to delimit the string:

```
const test = 'test'
const test = 'te\'st'
const test = 'te"st'
const test = "te\"st"
const test = "te'st"
```

There are various style guides that recommend always using one style vs the other.

I personally prefer single quotes all the time, and use double quotes only in HTML.

Backticks are a recent addition to JavaScript, since they were introduced with ES6 in 2015.

They have a unique feature: they allow multiline strings.

Multiline strings are also possible using regular strings, using escape characters:

```
const multilineString = 'A string\non multiple lines'
```

Using backticks, you can avoid using an escape character:

```
const multilineString = `A string
on multiple lines`
```

Not just that. You can interpolate variables using the `${}` syntax:

```
const multilineString = `A string
```

```
on ${1+1} lines`
```

I cover backticks-powered strings (called template literals) in a separate article, that dives more into the nitty-gritty details.

Functions

Learn all about functions, from the general overview to the tiny details that will improve how you use them

Introduction

Everything in JavaScript happens in functions.

A function is a block of code, self contained, that can be defined once and run any times you want.

A function can optionally accept parameters, and returns one value.

Functions in JavaScript are **objects**, a special kind of objects: **function objects**. Their superpower lies in the fact that they can be invoked.

In addition, functions are said to be **first class functions** because they can be assigned to a value, and they can be passed as arguments and used as a return value.

Syntax

Let's start with the "old", pre-ES6/ES2015 syntax. Here's a **function declaration**:

```
function dosomething(foo) {
  // do something
}
```

(now, in post ES6/ES2015 world, referred as a **regular function**)

Functions can be assigned to variables (this is called a **function expression**):

```
const dosomething = function(foo) {
  // do something
}
```

Named function expressions are similar, but play nicer with the stack call trace, which is useful when an error occurs - it holds the name of the function:

```
const dosomething = function dosomething(foo) {
  // do something
}
```

ES6/ES2015 introduced **arrow functions**, which are especially nice to use when working with inline functions, as parameters or callbacks:

```
const dosomething = foo => {
  //do something
}
```

Arrow functions have an important difference from the other function definitions above, we'll see which one later as it's an advanced topic.

Parameters

A function can have one or more parameters.

```
const dosomething = () => {
  //do something
}

const dosomethingElse = foo => {
  //do something
}

const dosomethingElseAgain = (foo, bar) => {
  //do something
}
```

Starting with ES6/ES2015, functions can have default values for the parameters:

```
const dosomething = (foo = 1, bar = 'hey') => {
  //do something
}
```

This allows you to call a function without filling all the parameters:

```
dosomething(3)
dosomething()
```

ES2018 introduced trailing commas for parameters, a feature that helps reducing bugs due to missing commas when moving around parameters (e.g. moving the last in the middle):

```
const dosomething = (foo = 1, bar = 'hey') => {
  //do something
}

dosomething(2, 'ho!')
```

You can wrap all your arguments in an array, and use the spread operator when calling the function:

```
const dosomething = (foo = 1, bar = 'hey') => {
  //do something
}
const args = [2, 'ho!']
dosomething(...args)
```

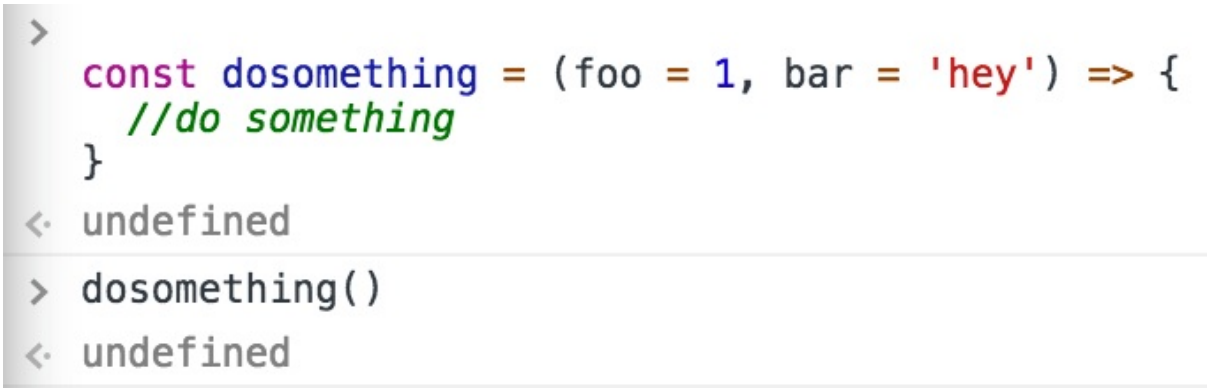
With many parameters, remembering the order can be difficult. Using objects, destructuring allows to keep the parameter names:

```
const dosomething = ({ foo = 1, bar = 'hey' }) => {
  //do something
```

```
  console.log(foo) // 2
  console.log(bar) // 'ho!'
}
const args = { foo: 2, bar: 'ho!' }
dosomething(args)
```

Return values

Every function returns a value, which by default is `undefined`.



Any function is terminated when its lines of code end, or when the execution flow finds a `return` keyword.

When JavaScript encounters this keyword it exits the function execution and gives control back to its caller.

If you pass a value, that value is returned as the result of the function:

```
const dosomething = () => {
  return 'test'
}
const result = dosomething() // result === 'test'
```

You can only return one value.

To *simulate* returning multiple values, you can return an **object literal**, or an **array**, and use a destructuring assignment when calling the function.

Using arrays:

```
> const dosomething = () => {
    return ['Roger', 6]
  }
  const [ name, age ] = dosomething()
<· undefined
> name
<· "Roger"
> age
<· 6
```

Using objects:

```
> const dosomething = () => {
    return { name: 'Roger', age: 6 }
  }
  const { name, age } = dosomething()
<· undefined
> name
<· "Roger"
> age
<· 6
```

Nested functions

Functions can be defined inside other functions:

```
const dosomething = () => {
  const dosomethingelse = () => {}
  dosomethingelse()
  return 'test'
}
```

The nested function is scoped to the outside function, and cannot be called from the outside.

Object Methods

When used as object properties, functions are called methods:

```
const car = {
  brand: 'Ford',
  model: 'Fiesta',
  start: function() {
    console.log(`Started`)
  }
}

car.start()
```

`this` in Arrow Functions

There's an important behavior of Arrow Functions vs regular Functions when used as object methods. Consider this example:

```
const car = {
  brand: 'Ford',
  model: 'Fiesta',
  start: function() {
    console.log(`Started ${this.brand} ${this.model}`)
  },
  stop: () => {
    console.log(`Stopped ${this.brand} ${this.model}`)
  }
}
```

The `stop()` method does not work as you would expect.

```
> const car = {
    brand: 'Ford',
    model: 'Fiesta',
    start: function() {
      console.log(`Started ${this.brand} ${this.model}`)
    },
    stop: () => {
      console.log(`Stopped ${this.brand} ${this.model}`)
    }
  }

  car.start()
  car.stop()
```

```
  Started Ford Fiesta
```

```
  Stopped undefined undefined
```

This is because the handling of `this` is different in the two functions declarations style. `this` in the arrow function refers to the enclosing function context, which in this case is the `window` object:

```
const car = {
  brand: 'Ford',
  model: 'Fiesta',
  start: function() {
    console.log(this)
    console.log(`Started ${this.brand} ${this.model}`)
  },
  stop: () => {
    console.log(this)
    console.log(`Stopped ${this.brand} ${this.model}`)
  }
}

car.start()
car.stop()
```

```
▶ {brand: "Ford", model: "Fiesta", start: f, stop: f}
```

```
Started Ford Fiesta
```

```
▶ Window {postMessage: f, blur: f, focus: f, close: f,
  , …}
```

```
Stopped undefined undefined
```

`this`, which refers to the host object using `function()`

This implies that **arrow functions are not suitable to be used for object methods** and constructors (arrow function constructors will actually raise a `TypeError` when called).

IIFE, Immediately Invocated Function Expressions

An IIFE is a function that's immediately executed right after its declaration:

```
;(function dosomething() {
  console.log('executed')
})()
```

You can assign the result to a variable:

```
const something = (function dosomething() {
  return 'something'
})()
```

They are very handy, as you don't need to separately call the function after its definition.

Function Hoisting

JavaScript before executing your code reorders it according to some rules.

Functions in particular are moved at the top of their scope. This is why it's legal to write

```
dosomething()
function dosomething() {
  console.log('did something')
}
```

```
> dosomething()
  function dosomething() {
    console.log('did something')
  }
  did something
```

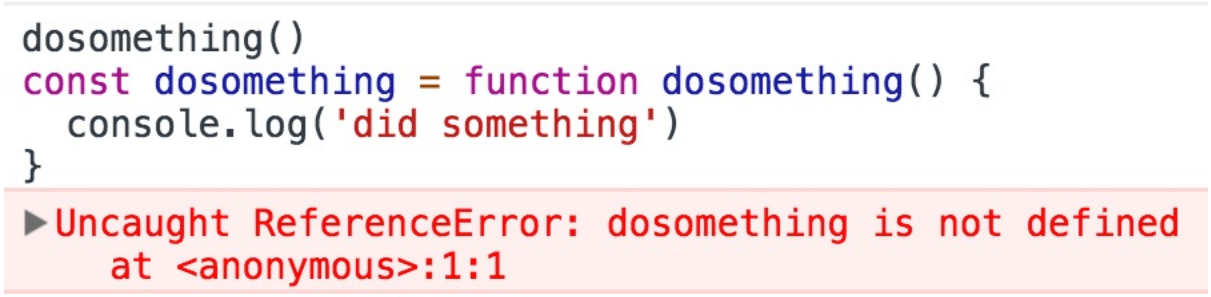
Internally, JavaScript moves the function before its call, along with all the other functions found in the same scope:

```
function dosomething() {
  console.log('did something')
}
dosomething()
```

Now, if you use named function expressions, since you're using variables something different happens. The variable declaration is hoisted, but not the value, so not the function.

```
dosomething()
const dosomething = function dosomething() {
  console.log('did something')
}
```

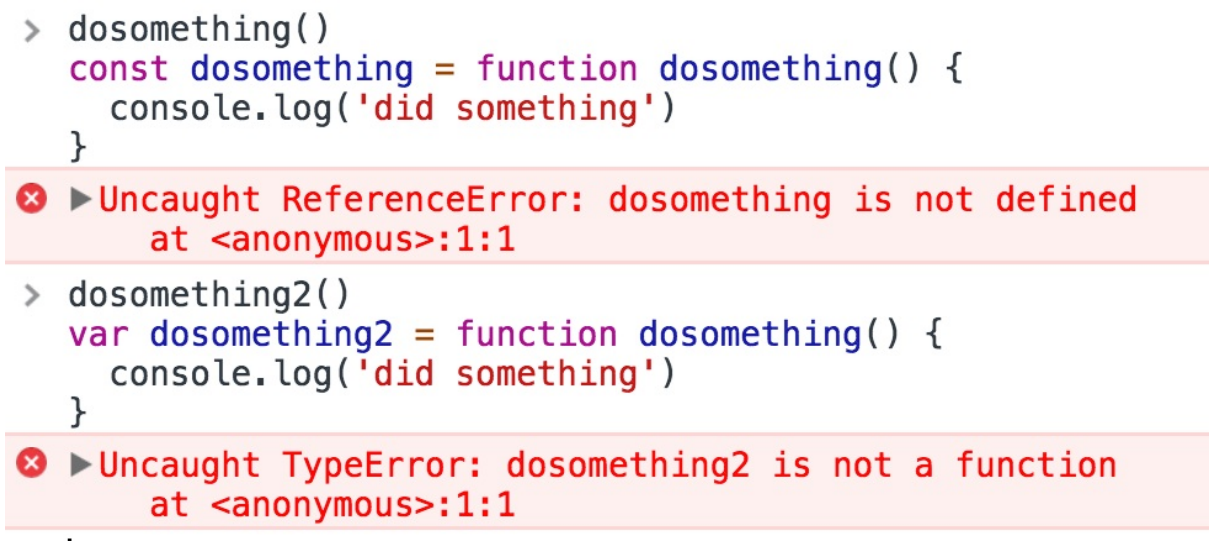
Not going to work:



This is because what happens internally is:

```
const dosomething
dosomething()
dosomething = function dosomething() {
  console.log('did something')
}
```

The same happens for `let` declarations. `var` declarations do not work either, but with a different error:



This is because `var` declarations are hoisted and initialized with `undefined` as a value, while `const` and `let` are hoisted but not initialized.

Arrow Functions

Arrow Functions are one of the most impactful changes in ES6/ES2015, and they are widely used nowadays. They slightly differ from regular functions. Find out how

Arrow functions were introduced in ES6 / ECMAScript 2015, and since their introduction they changed forever how JavaScript code looks (and works).

In my opinion this change was so welcoming that you now rarely see in modern codebases the usage of the `function` keyword.

Visually, it's a simple and welcome change, which allows you to write functions with a shorter syntax, from:

```
const myFunction = function foo() {
  //...
}
```

to

```
const myFunction = () => {
  //...
}
```

If the function body contains just a single statement, you can omit the parentheses and write all on a single line:

```
const myFunction = () => doSomething()
```

Parameters are passed in the parentheses:

```
const myFunction = (param1, param2) => doSomething(param1, param2)
```

If you have one (and just one) parameter, you could omit the parentheses completely:

```
const myFunction = param => doSomething(param)
```

Thanks to this short syntax, arrow functions **encourage the use of small functions**.

Implicit return

Arrow functions allow you to have an implicit return: values are returned without having to use the `return` keyword.

It works when there is a on-line statement in the function body:

```
const myFunction = () => 'test'

myFunction() //'test'
```

Another example, returning an object (remember to wrap the curly brackets in parentheses to avoid it being considered the wrapping function body brackets):

```
const myFunction = () => ({value: 'test'})

myFunction() //{value: 'test'}
```

How `this` works in arrow functions

`this` is a concept that can be complicated to grasp, as it varies a lot depending on the context and also varies depending on the mode of JavaScript (*strict mode* or not).

It's important to clarify this concept because arrow functions behave very differently compared to regular functions.

When defined as a method of an object, in a regular function `this` refers to the object, so you can do:

```
const car = {
  model: 'Fiesta',
  manufacturer: 'Ford',
  fullName: function() {
    return `${this.manufacturer} ${this.model}`
  }
}
```

calling `car.fullName()` will return `"Ford Fiesta"`.

The `this` scope with arrow functions is **inherited** from the execution context. An arrow function does not bind `this` at all, so its value will be looked up in the call stack, so in this code `car.fullName()` will not work, and will return the string `"undefined undefined"`:

```
const car = {
  model: 'Fiesta',
  manufacturer: 'Ford',
  fullName: () => {
```

```
    return `${this.manufacturer} ${this.model}`
  }
}
```

Due to this, arrow functions are not suited as object methods.

Arrow functions cannot be used as constructors as well, when instantiating an object will raise a `TypeError`.

This is where regular functions should be used instead, **when dynamic context is not needed**.

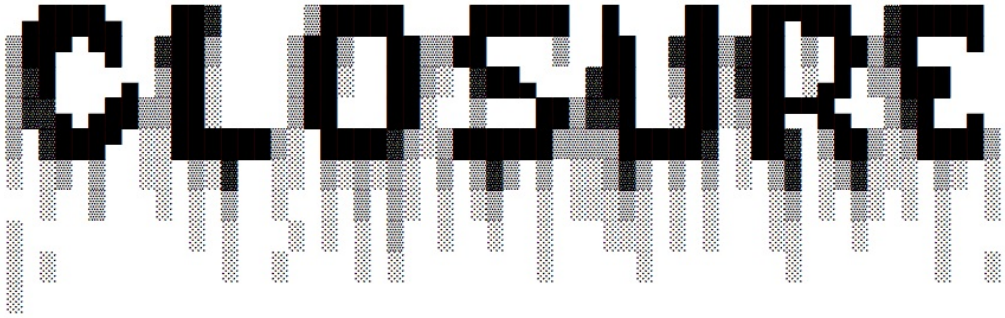
This is also a problem when handling events. DOM Event listeners set `this` to be the target element, and if you rely on `this` in an event handler, a regular function is necessary:

```
const link = document.querySelector('#link')
link.addEventListener('click', () => {
  // this === window
})
```

```
const link = document.querySelector('#link')
link.addEventListener('click', function() {
  // this === link
})
```

Closures

A gentle introduction to the topic of closures, key to understanding how JavaScript functions work



If you've ever written a function in JavaScript, you already made use of **closures**.

It's a key topic to understand, which has implications on the things you can do.

When a function is run, it's executed **with the scope that was in place when it was defined**, and *not* with the state that's in place when it is **executed**.

The scope basically is the set of variables which are visible.

A function remembers its Lexical Scope, and it's able to access variables that were defined in the parent scope.

In short, a function has an entire baggage of variables it can access.

Let me immediately give an example to clarify this.

```
const bark = dog => {
  const say = `${dog} barked!`
  ;(() => console.log(say))()
}

bark(`Roger`)
```

This logs to the console `Roger barked!`, as expected.

What if you want to return the action instead:

```
const prepareBark = dog => {
  const say = `${dog} barked!`
  return () => console.log(say)
}

const bark = prepareBark(`Roger`)

bark()
```

This snippet also logs to the console `Roger barked!`.

Let's make one last example, which reuses `prepareBark` for two different dogs:

```
const prepareBark = dog => {
  const say = `${dog} barked!`
  return () => {
    console.log(say)
  }
}

const rogerBark = prepareBark(`Roger`)
const sydBark = prepareBark(`Syd`)

rogerBark()
sydBark()
```

This prints

```
Roger barked!
Syd barked!
```

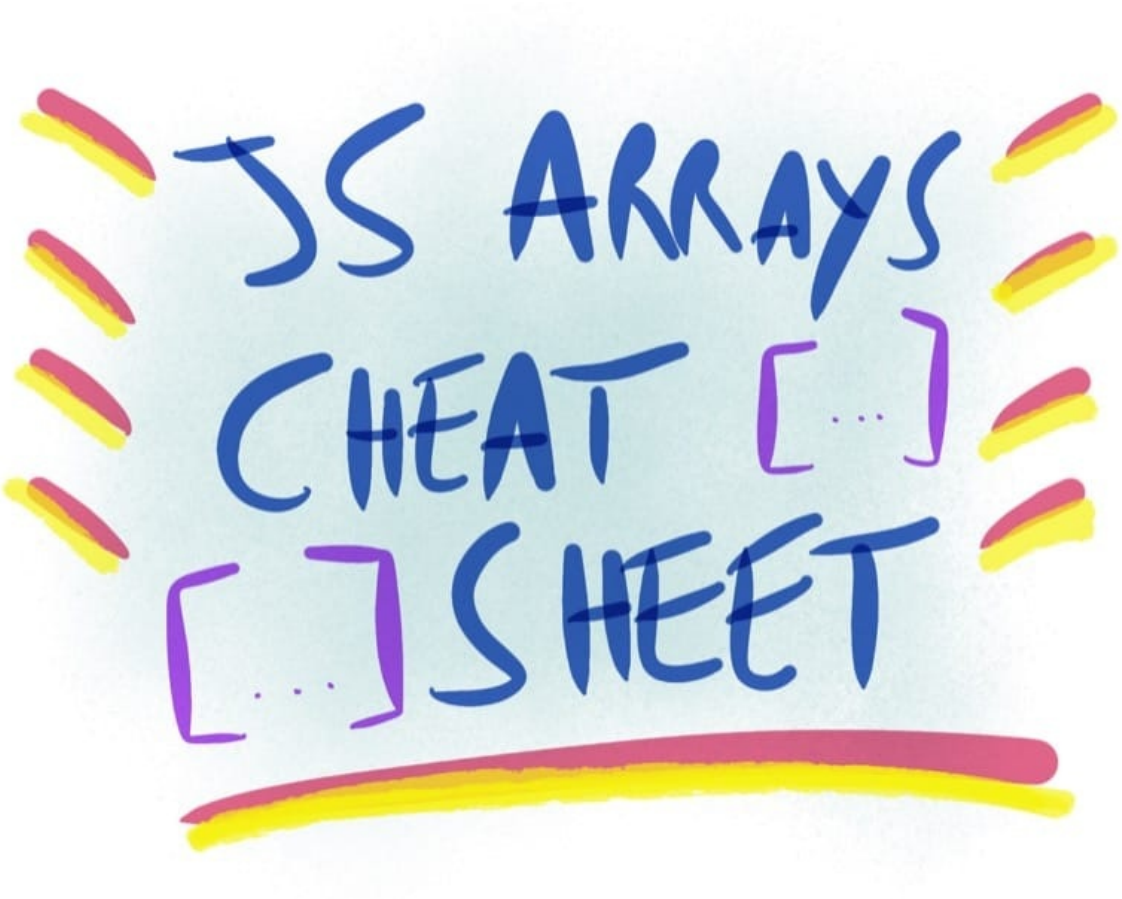
As you can see, the **state** of the variable `say` is linked to the function that's returned from `prepareBark()`.

Also notice that we redefine a new `say` variable the second time we call `prepareBark()`, but that does not affect the state of the first `prepareBark()` scope.

This is how a closure works: the function that's returned keeps the original state in its scope.

Arrays

JavaScript arrays over time got more and more features, sometimes it's tricky to know when to use some construct vs another. This post aims to explain what you should use, as of 2018



JavaScript arrays over time got more and more features, sometimes it's tricky to know when to use some construct vs another. This post aims to explain what you should use in 2018.

Initialize array

```
const a = []
const a = [1, 2, 3]
const a = Array.of(1, 2, 3)
const a = Array(6).fill(1) //init an array of 6 items of value 1
```

Don't use the old syntax (just use it for typed arrays)

```
const a = new Array() //never use
const a = new Array(1, 2, 3) //never use
```

Get length of the array

```
const l = a.length
```

Iterating the array

Every

```
a.every(f)
```

Iterates `a` until `f()` returns false

Some

```
a.some(f)
```

Iterates `a` until `f()` returns true

Iterate the array and return a new one with the returned result of a function

```
const b = a.map(f)
```

Iterates `a` and builds a new array with the result of executing `f()` on each `a` element

Filter an array

```
const b = a.filter(f)
```

Iterates `a` and builds a new array with elements of `a` that returned true when executing `f()` on each `a` element

Reduce

```
a.reduce((accumulator, currentValue, currentIndex, array) => {
  //...
}, initialValue)
```

`reduce()` executes a callback function on all the items of the array and allows to progressively compute a result. If `initialValue` is specified, `accumulator` in the first iteration will equal to that value.

Example:

```
;[1, 2, 3, 4].reduce((accumulator, currentValue, currentIndex, array) => {
  return accumulator * currentValue
```

```
}, 1)

// iteration 1: 1 * 1 => return 1
// iteration 2: 1 * 2 => return 2
// iteration 3: 2 * 3 => return 6
// iteration 4: 6 * 4 => return 24

// return value is 24
```

forEach

> ES6

```
a.forEach(f)
```

Iterates `f` on `a` without a way to stop

Example:

```
a.forEach(v => {
  console.log(v)
})
```

for..of

> ES6

```
for (let v of a) {
  console.log(v)
}
```

for

```
for (let i = 0; i < a.length; i += 1) {
  //a[i]
}
```

Iterates `a`, can be stopped using `return` or `break` and an iteration can be skipped using `continue`

@@iterator

> ES6

Getting the iterator from an array returns an iterator of values

```
const a = [1, 2, 3]
let it = a[Symbol.iterator]()

console.log(it.next().value) //1
console.log(it.next().value) //2
console.log(it.next().value) //3
```

`.entries()` returns an iterator of key/value pairs

```
let it = a.entries()

console.log(it.next().value) //[0, 1]
console.log(it.next().value) //[1, 2]
console.log(it.next().value) //[2, 3]
```

`.keys()` allows to iterate on the keys:

```
let it = a.keys()

console.log(it.next().value) //0
console.log(it.next().value) //1
console.log(it.next().value) //2
```

`.next()` returns `undefined` when the array ends. You can also detect if the iteration ended by looking at `it.next()` which returns a `value, done` pair. `done` is always false until the last element, which returns `true`.

Adding to an array

Add a the end

```
a.push(4)
```

Add at the beginning

```
a.unshift(0)
a.unshift(-2, -1)
```

Removing an item from an array

From the end

```
a.pop()
```

From the beginning

```
a.shift()
```

At a random position

```
a.splice(0, 2) // get the first 2 items
a.splice(3, 2) // get the  2 items starting from index 3
```

Do not use `remove()` as it leaves behind undefined values.

Remove and insert in place

```
a.splice(2, 3, 2, 'a', 'b') //removes 3 items starting from
//index 2, and adds 2 items,
// still starting from index 2
```

Join multiple arrays

```
const a = [1, 2]
const b = [3, 4]
a.concat(b) // 1, 2, 3, 4
```

Lookup the array for a specific element

ES5

```
a.indexOf()
```

Returns the index of the first matching item found, or -1 if not found

```
a.lastIndexOf()
```

Returns the index of the last matching item found, or -1 if not found

ES6

```
a.find((element, index, array) => {
  //return true or false
})
```

Returns the first item that returns true. Returns undefined if not found.

A commonly used syntax is:

```
a.find(x => x.id === my_id)
```

The above line will return the first element in the array that has `id === my_id`.

`findIndex` returns the index of the first item that returns true, and if not found, it returns `undefined`:

```
a.findIndex((element, index, array) => {
  //return true or false
})
```

ES7

```
a.includes(value)
```

Returns true if `a` contains `value`.

```
a.includes(value, i)
```

Returns true if `a` contains `value` after the position `i`.

Get a portion of an array

```
a.slice()
```

Sort the array

Sort alphabetically (by ASCII value - `0-9A-Za-z`)

```
const a = [1, 2, 3, 10, 11]
a.sort() //1, 10, 11, 2, 3

const b = [1, 'a', 'Z', 3, 2, 11]
b = a.sort() //1, 11, 2, 3, Z, a
```

Sort by a custom function

```
const a = [1, 10, 3, 2, 11]
a.sort((a, b) => a - b) //1, 2, 3, 10, 11
```

Reverse the order of an array

```
a.reverse()
```

Get a string representation of an array

```
a.toString()
```

Returns a string representation of an array

```
a.join()
```

Returns a string concatenation of the array elements. Pass a parameter to add a custom separator:

```
a.join(', ')
```

Copy an existing array by value

```
const b = Array.from(a)
const b = Array.of(...a)
```

Copy just some values from an existing array

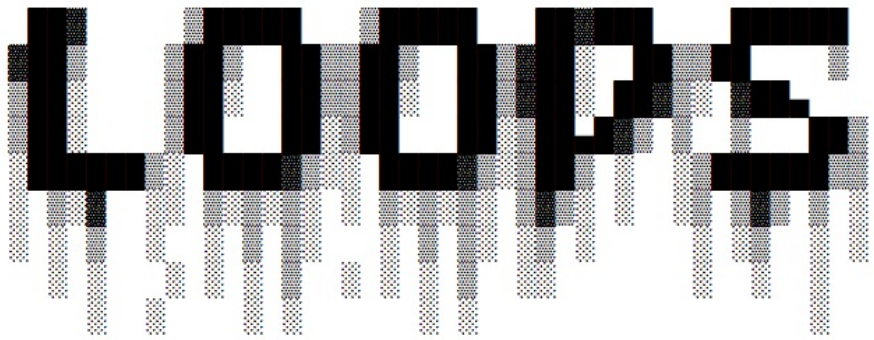
```
const b = Array.from(a, x => x % 2 == 0)
```

Copy portions of an array into the array itself, in other positions

```
const a = [1, 2, 3, 4]
a.copyWithin(0, 2) // [3, 4, 3, 4]
const b = [1, 2, 3, 4, 5]
b.copyWithin(0, 2) // [3, 4, 5, 4, 5]
//0 is where to start copying into,
// 2 is where to start copying from
const c = [1, 2, 3, 4, 5]
c.copyWithin(0, 2, 4) // [3, 4, 3, 4, 5]
//4  is an end index
```

Loops

JavaScript provides many way to iterate through loops. This tutorial explains all the various loop possibilities in modern JavaScript



Introduction

JavaScript provides many way to iterate through loops. This tutorial explains each one with a small example and the main properties.

`for`

```
const list = ['a', 'b', 'c']
for (let i = 0; i < list.length; i++) {
  console.log(list[i]) //value
  console.log(i) //index
}
```

- You can interrupt a `for` loop using `break`
- You can fast forward to the next iteration of a `for` loop using `continue`

forEach

Introduced in ES5. Given an array, you can iterate over its properties using `list.forEach()`:

```
const list = ['a', 'b', 'c']
list.forEach((item, index) => {
  console.log(item) //value
  console.log(index) //index
})

//index is optional
list.forEach(item => console.log(item))
```

unfortunately you cannot break out of this loop.

`do...while`

```
const list = ['a', 'b', 'c']
let i = 0
do {
  console.log(list[i]) //value
  console.log(i) //index
  i = i + 1
} while (i < list.length)
```

You can interrupt a `while` loop using `break`:

```
do {
  if (something) break
} while (true)
```

and you can jump to the next iteration using `continue`:

```
do {
  if (something) continue
```

```
  //do something else
} while (true)
```

while

```
const list = ['a', 'b', 'c']
let i = 0
while (i < list.length) {
  console.log(list[i]) //value
  console.log(i) //index
  i = i + 1
}
```

You can interrupt a `while` loop using `break`:

```
while (true) {
  if (something) break
}
```

and you can jump to the next iteration using `continue`:

```
while (true) {
  if (something) continue

  //do something else
}
```

The difference with `do...while` is that `do...while` always execute its cycle at least once.

for...in

Iterates all the enumerable properties of an object, giving the property names.

```
for (let property in object) {
  console.log(property) //property name
  console.log(object[property]) //property value
}
```

for...of

ES2015 introduced the `for...of` loop, which combines the conciseness of forEach with the ability to break:

```
//iterate over the value
for (const value of ['a', 'b', 'c']) {
  console.log(value) //value
}

//get the index as well, using `entries()`
for (const [index, value] of ['a', 'b', 'c'].entries()) {
  console.log(index) //index
  console.log(value) //value
}
```

Notice the use of `const`. This loop creates a new scope in every iteration, so we can safely use that instead of `let`.

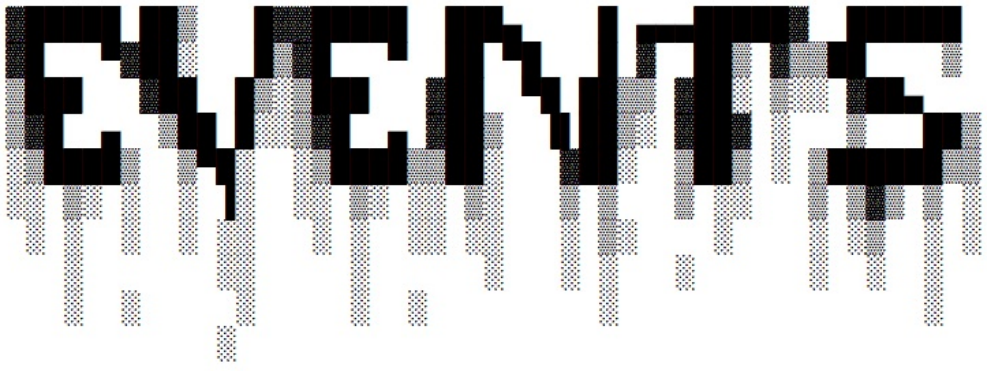
`for...in` vs `for...of`

The difference with `for...in` is:

- `for...of` **iterates over the property values**
- `for...in` **iterates the property names**

Events

JavaScript in the browser uses an event-driven programming model. Everything starts by following an event. This is an introduction to JavaScript events and how event handling works



Introduction

JavaScript in the browser uses an event-driven programming model.

Everything starts by following an event.

The event could be the DOM is loaded, or an asynchronous request that finishes fetching, or a user clicking an element or scrolling the page, or the user types on the keyboard.

There are a lot of different kind of events.

Event handlers

You can respond to any event using an **Event Handler**, which is just a function that's called when an event occurs.

You can register multiple handlers for the same event, and they will all be called when that event happens.

JavaScript offer three ways to register an event handler:

Inline event handlers

This style of event handlers is very rarely used today, due to its constrains, but it was the only way in the JavaScript early days:

```
<a href="site.com" onclick="dosomething();">A link</a>
```

DOM on-event handlers

This is common when an object has at most one event handler, as there is no way to add multiple handlers in this case:

```
window.onload = () => {
  //window loaded
}
```

It's most commonly used when handling XHR requests:

```
const xhr = new XMLHttpRequest()
xhr.onreadystatechange = () => {
  //.. do something
}
```

You can check if an handler is already assigned to a property using `if ('onsomething' in window) {}`.

Using `addEventListener()`

This is the *modern way*. This method allows to register as many handlers as we need, and it's the most popular you will find:

```
window.addEventListener('load', () => {
  //window loaded
})
```

This method allows to register as many handlers as we need, and it's the most popular you will find.

> Note that IE8 and below did not support this, and instead used its own `attachEvent()` API. Keep it in mind if you need to support older browsers.

Listening on different elements

You can listen on `window` to intercept "global" events, like the usage of the keyboard, and you can listen on specific elements to check events happening on them, like a mouse click on a button.

This is why `addEventListener` is sometimes called on `window`, sometimes on a DOM element.

The Event object

An event handler gets an `Event` object as the first parameter:

```
const link = document.getElementById('my-link')
link.addEventListener('click', event => {
  // link clicked
})
```

This object contains a lot of useful properties and methods, like:

- `target`, the DOM element that originated the event
- `type`, the type of event
- `stopPropagation()`, called to stop propagating the event in the DOM

(see the full list).

Other properties are provided by specific kind of events, as `Event` is an interface for different specific events:

- MouseEvent
- KeyboardEvent
- DragEvent
- FetchEvent
- ... and others

Each of those has a MDN page linked, so you can inspect all their properties.

For example when a KeyboardEvent happens, you can check which key was pressed, in ar readable format (`Escape` , `Enter` and so on) by checking the `key` property:

```
window.addEventListener('keydown', event => {
  // key pressed
  console.log(event.key)
})
```

On a mouse event we can check which mouse button was pressed:

```
const link = document.getElementById('my-link')
link.addEventListener('mousedown', event => {
  // mouse button pressed
  console.log(event.button) //0=left, 2=right
})
```

Event bubbling and event capturing

Bubbling and capturing are the 2 models that events use to propagate.

Suppose you DOM structure is

```
<div id="container">
  <button>Click me</button>
</div>
```

You want to track when users click on the button, and you have 2 event listeners, one on `button` , and one on `#container` . Remember, a click on a child element will always propagate to its parents, unless you stop the propagation (see later).

Those event listeners will be called in order, and this order is determined by the event bubbling/capturing model used.

Bubbling means that the event propagates from the item that was clicked (the child) up to all its parent tree, starting from the nearest one.

In our example, the handler on `button` will fire before the `#container` handler.

Capturing is the opposite: the outer event handlers are fired before the more specific handler, the one on `button`.

By default all events bubble.

You can choose to adopt event capturing by applying a third argument to addEventListener, setting it to `true`:

```
document.getElementById('container').addEventListener(
  'click',
  () => {
    //window loaded
  },
  true
)
```

Note that **first all capturing event handlers are run**.

Then all the bubbling event handlers.

The order follows this principle: the DOM goes through all elements starting from the Window object, and goes to find the item that was clicked. While doing so, it calls any event handler associated to the event (capturing phase).

Once it reaches the target, it then repeats the journey up to the parents tree until the Window object, calling again the event handlers (bubbling phase).

Stopping the propagation

An event on a DOM element will be propagated to all its parent elements tree, unless it's stopped.

```
<html>
  <body>
    <section>
      <a id="my-link" ...>
```

A click event on `a` will propagate to `section` and then `body`.

You can stop the propagation by calling the `stopPropagation()` method of an Event, usually at the end of the event handler:

```
const link = document.getElementById('my-link')
link.addEventListener('mousedown', event => {
  // process the event
  // ...

  event.stopPropagation()
})
```

Popular events

Here's a list of the most common events you will likely handle.

Load

`load` is fired on `window` and the `body` element when the page has finished loading.

Mouse events

`click` fires when a mouse button is clicked. `dblclick` when the mouse is clicked two times. Of course in this case `click` is fired just before this event. `mousedown`, `mousemove` and `mouseup` can be used in combination to track drag-and-drop events. Be careful with `mousemove`, as it fires many times during the mouse movement (see *debouncing* later)

Keyboard events

`keydown` fires when a keyboard button is pressed (and any time the key repeats while the button *stays* pressed). `keyup` is fired when the key is released.

Scroll

The `scroll` event is fired on `window` every time you scroll the page. Inside the event handler you can check the current scrolling position by checking `window.scrollY`.

Keep in mind that this event is not a one-time thing. It fires a lot of times during scrolling, not just at the end or beginning of the scrolling, so don't do any heavy computation or manipulation in the handler - use *debouncing* instead.

Debouncing

As we mentioned above, `mousemove` and `scroll` are two events that are not fired one-time per event, but rather they continuously call their event handler function during all the duration of the action.

This is because they provide coordinates so you can track what's happening.

If you perform a complex operation in the event handler, you will affect the performance and cause a sluggish experience to your site users.

Libraries that provide debouncing like Lodash implement it in 100+ lines of code, to handle every possible use case. A simple and easy to understand implementation is this, which uses setTimeout to cache the scroll event every 100ms:

```
let cached = null
window.addEventListener('scroll', event => {
  if (!cached) {
    setTimeout(() => {
      //you can access the original event at `cached`
      cached = null
    }, 100)
  }
  cached = event
})
```

The Event Loop

The Event Loop is one of the most important aspects to understand about JavaScript. This post explains it in simple terms

Introduction

The **Event Loop** is one of the most important aspects to understand about JavaScript.

> I've programmed for years with JavaScript, yet I've never *fully* understood how things work under the hoods. It's completely fine to not know this concept in details, but as usual it's helpful to know how it works, and also you might just be a little curious at this point.

This post aims to explain the inner details of how JavaScript works with a single thread, and how it handles asynchronous functions.

Your JavaScript code runs single threaded. There is just one thing happening at a time.

This is a limitation that's actually very helpful, as it simplifies a lot how you program without worrying about concurrency issues.

You just need to pay attention to how you write your code, and avoid anything that could block the thread, like synchronous network calls or infinite loops.

In general, in most browsers there is an event loop for every browser tab, to make every process isolated and avoid a web page with infinite loops or heavy processing to block your entire browser.

The environment manages multiple concurrent event loops, to handle API calls for example. Web Workers run in their own event loop as well.

You mainly need to be concerned that *your code* will run on a single event loop, and write code with this thing in mind to avoid blocking it.

Blocking the event loop

Any JavaScript code that takes too long to return back control to the event loop will block the execution of any JavaScript code in the page, even block the UI thread, and the user cannot click around, scroll the page, and so on.

Almost all the I/O primitives in JavaScript are non-blocking. Network requests, Node.js filesystem operations, and so on. Being blocking is the exception, and this is why JavaScript is based so much on callbacks, and more recently on promises and async/await.

The call stack

The call stack is a LIFO queue (Last In, First Out).

The event loop continuously checks the **call stack** to see if there's any function that needs to run.

While doing so, it adds any function call it finds to the call stack, and executes each one in order.

You know the error stack trace you might be familiar with, in the debugger or in the browser console? The browser looks up the function names in the call stack to inform you which function originates the current call:

A simple event loop explanation

Let's pick an example:

```
const bar = () => console.log('bar')

const baz = () => console.log('baz')

const foo = () => {
  console.log('foo')
  bar()
  baz()
}

foo()
```

This code prints

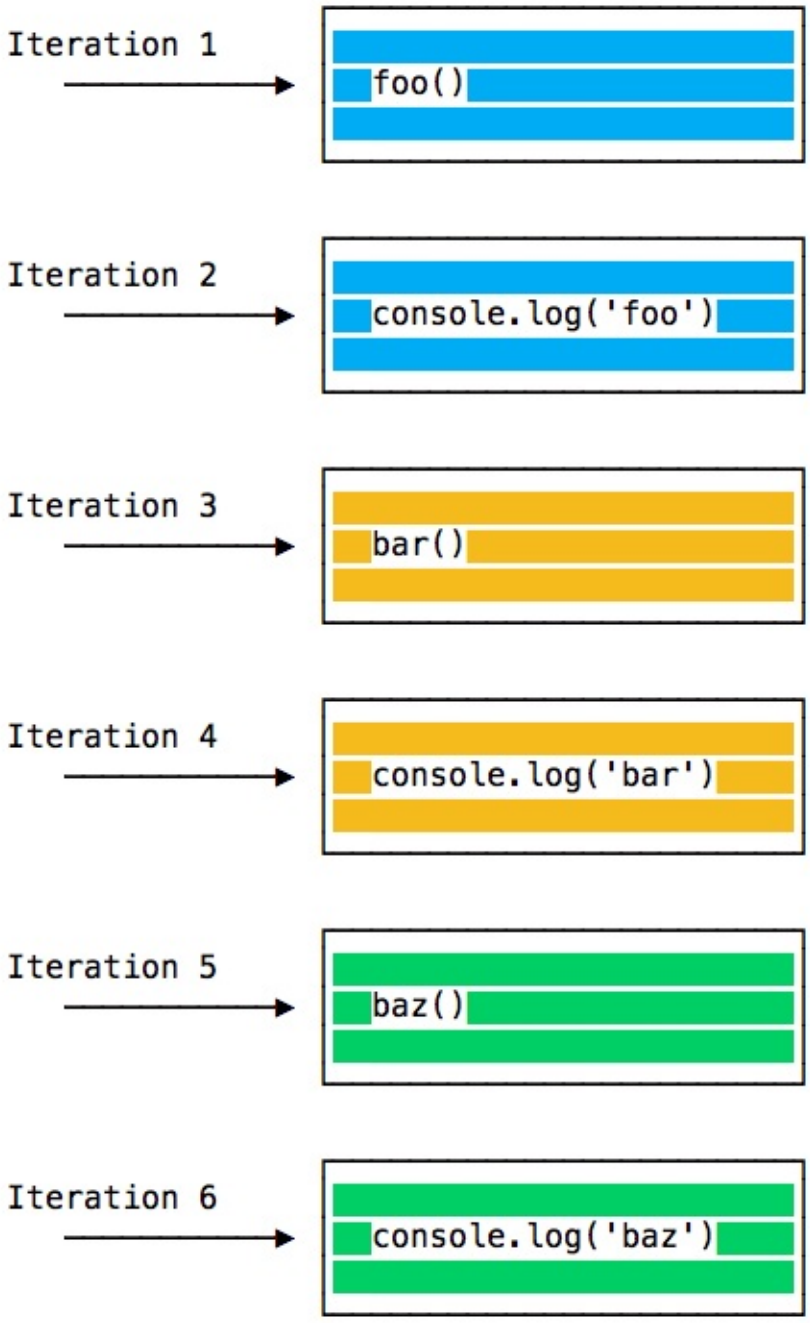
```
foo
bar
baz
```

as expected.

When this code runs, first `foo()` is called. Inside `foo()` we first call `bar()`, then we call `baz()`.

At this point the call stack looks like this:

The event loop on every iteration looks if there's something in the call stack, and executes it:



until the call stack is empty.

Queuing function execution

The above example looks normal, there's nothing special about it: JavaScript finds things to execute, runs them in order.

Let's see how to defer a function until the stack is clear.

The use case of `setTimeout(() => {}), 0)` is to call a function, but execute it once every other function in the code has executed.

Take this example:

```
const bar = () => console.log('bar')

const baz = () => console.log('baz')

const foo = () => {
  console.log('foo')
  setTimeout(bar, 0)
  baz()
}

foo()
```

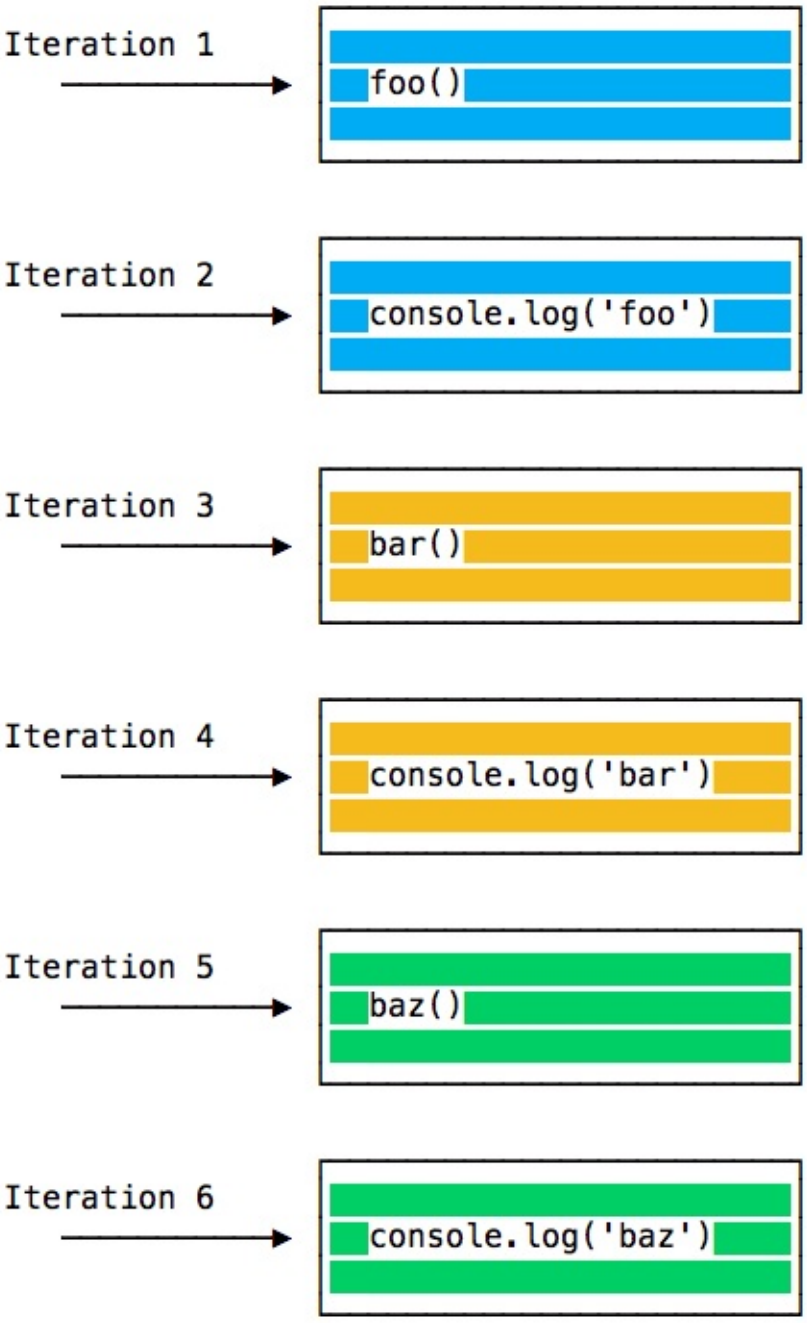
This code prints, maybe surprisingly:

```
foo
baz
bar
```

When this code runs, first foo() is called. Inside foo() we first call setTimeout, passing `bar` as an argument, and we instruct it to run immediately as fast as it can, passing 0 as the timer. Then we call baz().

At this point the call stack looks like this:

Here is the execution order for all the functions in our program:



Why is this happening?

The Message Queue

When setTimeout() is called, the Browser or Node.js start the timer. Once the timer expires, in this case immediately as we put 0 as the timeout, the callback function is put in the **Message Queue**.

The Message Queue is also where user-initiated events like click or keyboard events, or fetch responses are queued before your code has the opportunity to react to them. Or also DOM events like `onLoad`.

The loop gives priority to the call stack, and it first processes everything it finds in the call stack, and once there's nothing in there, it goes to pick up things in the event queue.

We don't have to wait for functions like `setTimeout`, fetch or other things to do their own work, because they are provided by the browser, and they live on their own threads. For example if you set the `setTimeout` timeout to 2 seconds, you don't have to wait 2 seconds - the wait happens elsewhere.

ES6 Job Queue

ECMAScript 2015 introduced the concept of the Job Queue, which is used by Promises (also introduced in ES6/ES2015). It's a way to execute the result of an async function as soon as possible, rather than being put at the end of the call stack.

Promises that resolve before the current function ends will be executed right after the current function.

I find nice the analogy of a rollercoaster ride at an amusement park: the message queue puts you back in queue with after all the other people in queue, while the job queue is the fastpass ticket that lets you take another ride right after you finished the previous one.

Example:

```
const bar = () => console.log('bar')

const baz = () => console.log('baz')

const foo = () => {
  console.log('foo')
  setTimeout(bar, 0)
  new Promise((resolve, reject) =>
    resolve('should be right after baz, before bar')
  ).then(resolve => console.log(resolve))
  baz()
}

foo()
```

This prints

```
foo
```

```
baz
should be right after foo, before bar
bar
```

That's a big difference between Promises (and Async/await, which is built on promises) and plain old asynchronous functions through `setTimeout()` or other platform APIs.

Asynchronous programming and callbacks

JavaScript is synchronous by default, and is single threaded. This means that code cannot create new threads and run in parallel. Find out what asynchronous code means and how it looks like

Asynchronicity in Programming Languages

Computers are asynchronous by design.

Asynchronous means that things can happen independently of the main program flow.

In the current consumer computers, every program runs for a specific time slot, and then it stops its execution to let another program continue its execution. This thing runs in a cycle so fast that's impossible to notice, and we think our computers run many programs simultaneously, but this is an illusion (except on multiprocessor machines).

Programs internally use *interrupts*, a signal that's emitted to the processor to gain the attention of the system.

I won't go into the internals of this, but just keep in mind that it's normal for programs to be asynchronous, and halt their execution until they need attention, and the computer can execute other things in the meantime. When a program is waiting for a response from the network, it cannot halt the processor until the request finishes.

Normally, programming languages are synchronous, and some provide a way to manage asynchronicity, in the language or through libraries. C, Java, C#, PHP, Go, Ruby, Swift, Python, they are all synchronous by default. Some of them handle async by using threads, spawning a new process.

JavaScript

JavaScript is **synchronous** by default, and is single threaded. This means that code cannot create new threads and run in parallel.

Lines of code are executed in series, one after another, for example:

```
const a = 1
const b = 2
const c = a * b
console.log(c)
doSomething()
```

But JavaScript was born inside the browser, its main job in the beginning was to respond to user actions, like `onClick`, `onMouseOver`, `onChange`, `onSubmit` and so on. How could it do this with a synchronous programming model?

The answer was in its environment. The **browser** provides a way to do it by providing a set of APIs that can handle this kind of functionality.

More recently, Node.js introduced a non-blocking I/O environment to extend this concept to file access, network calls and so on.

Callbacks

You can't know when a user is going to click a button, so what you do is, you **define an event handler for the click event**. This event handler accepts a function, which will be called when the event is triggered:

```
document.getElementById('button').addEventListener('click', () => {
  //item clicked
})
```

This is the so called **callback**.

A callback is a simple function that's passed as a value to another function, and will only be executed when the event happens. We can do this because JavaScript has first class functions, which can be assigned to variables and passed around to other functions (called **higher-order functions**)

It's common to wrap all your client code in a `load` event listener on the `window` object, which runs the callback function only when the page is ready:

```
window.addEventListener('load', () => {
  //window loaded
  //do what you want
})
```

Callbacks are used everywhere, not just in DOM events.

One common example is by using timers:

```
setTimeout(() => {
  // runs after 2 seconds
}, 2000)
```

XHR requests also accept a callback, in this example by assigning a function to a property that will be called when a particular even occurs (in this case, the state of the request changes):

```
const xhr = new XMLHttpRequest()
xhr.onreadystatechange = () => {
  if (xhr.readyState === 4) {
    xhr.status === 200 ? console.log(xhr.responseText) : console.error('error')
  }
}
xhr.open('GET', 'https://yoursite.com')
xhr.send()
```

Handling errors in callbacks

How do you handle errors with callbacks? One very common strategy is to use what Node.js adopted: the first parameter in any callback function is the error object: **error-first callbacks**

If there is no error, the object is `null`. If there is an error, it contains some description of the error, and other information.

```
fs.readFile('/file.json', (err, data) => {
  if (err !== null) {
    //handle error
    console.log(err)
    return
  }

  //no errors, process data
  console.log(data)
})
```

The problem with callbacks

Callbacks are great for simple cases!

However every callback adds a level of nesting, and when you have lots of callbacks, the code starts to be complicated very quickly:

```
window.addEventListener('load', () => {
  document.getElementById('button').addEventListener('click', () => {
    setTimeout(() => {
      items.forEach(item => {
        //your code here
      })
    }, 2000)
  })
})
```

This is just a simple 4-levels code, but I've seen much more levels of nesting and it's not fun.

How do we solve this?

Alternatives to callbacks

Starting with ES6, JavaScript introduced several features that help us with asynchronous code that do not involve using callbacks:

- Promises (ES6) and **Generators**
- Async/Await (ES8)

Promises

Promises are one way to deal with asynchronous code in JavaScript, without writing too many callbacks in your code.

Introduction to promises

A promise is commonly defined as **a proxy for a value that will eventually become available**.

Promises are one way to deal with asynchronous code, without writing too many callbacks in your code.

Although being around since years, they have been standardized and introduced in ES2015, and now they have been superseded in ES2017 by async functions.

Async functions use the promises API as their building block, so understanding them is fundamental even if in newer code you'll likely use async functions instead of promises.

How promises work, in brief

Once a promise has been called, it will start in **pending state**. This means that the caller function continues the execution, while it waits for the promise to do its own processing, and give the caller function some feedback.

At this point the caller function waits for it to either return the promise in a **resolved state**, or in a **rejected state**, but as you know JavaScript is asynchronous, so *the function continues its execution while the promise does it work*.

Which JS API use promises?

In addition to your own code, and libraries code, promises are used by standard modern Web APIs such as:

- the Battery API
- the Fetch API
- Service Workers

It's unlikely that in modern JavaScript you'll find yourself *not* using promises, so let's start diving right into them.

Creating a promise

The Promise API exposes a Promise constructor, which you initialize using `new Promise()`:

```
let done = true

const isItDoneYet = new Promise(
  (resolve, reject) => {
    if (done) {
      const workDone = 'Here is the thing I built'
      resolve(workDone)
    } else {
      const why = 'Still working on something else'
      reject(why)
    }
  }
)
```

As you can see the promise checks the `done` global constant, and if that's true, we return a resolved promise, otherwise a rejected promise.

Using `resolve` and `reject` we can communicate back a value, in the above case we just return a string, but it could be an object as well.

Consuming a promise

In the last section we introduced how a promise is created.

Now let's see how the promise can be *consumed*, or used.

```
const isItDoneYet = new Promise(
  //...
)

const checkIfItsDone = () => {
  isItDoneYet
    .then((ok) => {
      console.log(ok)
    })
    .catch((err) => {
      console.error(err)
    })
}
```

Running `checkIfItsDone()` will execute the `isItDoneYet()` promise and will wait for it to resolve, using the `then` callback, and if there is any error, it will handle it in the `catch` callback.

Chaining promises

A promise can be returned to another promise, creating a chain of promises.

A great example of chaining promises is given by the Fetch API, a layer on top of the XMLHttpRequest API, which we can use to get a resource and queue a chain of promises to execute when the resource is fetched.

The Fetch API is a promise-based mechanism, and calling `fetch()` is equivalent to defining our own promise using `new Promise()`.

Example of chaining promises

```
const status = (response) => {
  if (response.status >= 200 && response.status < 300) {
    return Promise.resolve(response)
  }
  return Promise.reject(new Error(response.statusText))
}

const json = (response) => response.json()

fetch('/todos.json')
  .then(status)
```

```
  .then(json)
  .then((data) => { console.log('Request succeeded with JSON response', data) })
  .catch((error) => { console.log('Request failed', error) })
```

In this example, we call `fetch()` to get a list of TODO items from the `todos.json` file found in the domain root, and we create a chain of promises.

Running `fetch()` returns a response, which has many properties, and within those we reference:

- `status`, a numeric value representing the HTTP status code
- `statusText`, a status message, which is `OK` if the request succeeded

`response` also has a `json()` method, which returns a promise that will resolve with the content of the body processed and transformed as JSON.

So given those premises, this is what happens: the first promise in the chain is a function that we defined, called `status()`, that checks the response status and if it's not a success response (between 200 and 299), it rejects the promise.

This operation will cause the promise chain to skip all the chained promises listed and will skip directly to the `catch()` statement at the bottom, logging the `Request failed` text along with the error message.

If that succeeds instead, it calls the json() function we defined. Since the previous promise, when successful, returned the `response` object, we get it as an input to the second promise.

In this case we return the data JSON processed, so the third promise receives the JSON directly:

```
.then((data) => {
  console.log('Request succeeded with JSON response', data)
})
```

and we simply log it to the console.

Handling errors

In the example in the previous section we had a `catch` that was appended to the chain of promises.

When anything in the chain of promises fails and raises an error or rejects the promise, the control goes to the nearest `catch()` statement down the chain.

```
new Promise((resolve, reject) => {
  throw new Error('Error')
})
  .catch((err) => { console.error(err) })

// or

new Promise((resolve, reject) => {
  reject('Error')
})
  .catch((err) => { console.error(err) })
```

Cascading errors

If inside the `catch()` you raise an error, you can append a second `catch()` to handle it, and so on.

```
new Promise((resolve, reject) => {
  throw new Error('Error')
})
  .catch((err) => { throw new Error('Error') })
  .catch((err) => { console.error(err) })
```

Orchestrating promises

`Promise.all()`

If you need to synchronize different promises, `Promise.all()` helps you define a list of promises, and execute something when they are all resolved.

Example:

```
const f1 = fetch('/something.json')
const f2 = fetch('/something2.json')

Promise.all([f1, f2]).then((res) => {
    console.log('Array of results', res)
})
.catch((err) => {
  console.error(err)
})
```

The ES2015 destructuring assignment syntax allows you to also do

```
Promise.all([f1, f2]).then(([res1, res2]) => {
```

```
    console.log('Results', res1, res2)
})
```

You are not limited to using `fetch` of course, **any promise is good to go**.

`Promise.race()`

`Promise.race()` runs when the first of the promises you pass to it resolves, and it runs the attached callback just once, with the result of the first promise resolved.

Example:

```
const first = new Promise((resolve, reject) => {
    setTimeout(resolve, 500, 'first')
})
const second = new Promise((resolve, reject) => {
    setTimeout(resolve, 100, 'second')
})

Promise.race([first, second]).then((result) => {
  console.log(result) // second
})
```

Common errors

Uncaught TypeError: undefined is not a promise

If you get the `Uncaught TypeError: undefined is not a promise` error in the console, make sure you use `new Promise()` instead of just `Promise()`

Template Literals

Introduced in ES2015, aka ES6, Template Literals offer a new way to declare strings, but also some new interesting constructs which are already widely popular.

Introduction to Template Literals

Template Literals are a new ES2015 / ES6 feature that allow you to work with strings in a novel way compared to ES5 and below.

The syntax at a first glance is very simple, just use backticks instead of single or double quotes:

```
const a_string = `something`
```

They are unique because they provide a lot of features that normal strings built with quotes, in particular:

- they offer a great syntax to define multiline strings
- they provide an easy way to interpolate variables and expressions in strings
- they allow to create DSLs with template tags

Let's dive into each of these in details.

Multiline strings

Pre-ES6, to create a string spanned over two lines you had to use the `\` character at the end of a line:

```
const string = 'first part \
second part'
```

This allows to create a string on 2 lines, but it's rendered on just one line:

```
first part second part
```

To render the string on multiple lines as well, you explicitly need to add `\n` at the end of each line, like this:

```
const string = 'first line\n \
second line'
```

or

```
const string = 'first line\n' +
               'second line'
```

Template literals make multiline strings much simpler.

Once a template literal is opened with the backtick, you just press enter to create a new line, with no special characters, and it's rendered as-is:

```
const string = `Hey
this

string
is awesome!`
```

Keep in mind that space is meaningful, so doing this:

```
const string = `First
               Second`
```

is going to create a string like this:

```
First
               Second
```

an easy way to fix this problem is by having an empty first line, and appending the trim() method right after the closing backtick, which will eliminate any space before the first character:

```
const string = `
First
Second`.trim()
```

Interpolation

Template literals provide an easy way to interpolate variables and expressions into strings.

You do so by using the `${...}` syntax:

```
const var = 'test'
const string = `something ${var}` //something test
```

inside the `${}` you can add anything, even expressions:

```
const string = `something ${1 + 2 + 3}`
const string2 = `something ${foo() ? 'x' : 'y' }`
```

Template tags

Tagged templates is one features that might sound less useful at first for you, but it's actually used by lots of popular libraries around, like Styled Components or Apollo, the GraphQL client/server lib, so it's essential to understand how it works.

In Styled Components template tags are used to define CSS strings:

```
const Button = styled.button`
  font-size: 1.5em;
  background-color: black;
  color: white;
`;
```

In Apollo template tags are used to define a GraphQL query schema:

```
const query = gql`
  query {
    ...
  }
`
```

The `styled.button` and `gql` template tags highlighted in those examples are just **functions**:

```
function gql(literals, ...expressions) {

}
```

this function returns a string, which can be the result of *any* kind of computation.

`literals` is an array containing the template literal content tokenized by the expressions interpolations.

`expressions` contains all the interpolations.

If we take an example above:

```
const string = `something ${1 + 2 + 3}`
```

`literals` is an array with two items. The first is `something`, the string until the first interpolation, and the second is an empty string, the space betwene the end of the first interpolation (we only have one) and the end of the string.

`expressions` in this case is an array with a single item, `6`.

A more complex example is:

```
const string = `something
another ${'x'}
new line ${1 + 2 + 3}
test`
```

in this case `literals` is an array where the first item is:

```
`something
another `
```

the second is:

```
`
new line `
```

and the third is:

```
`
test`
```

`expressions` in this case is an array with two items, `x` and `6`.

The function that is passed those values can do anything with them, and this is the power of this kind feature.

The most simple example is replicating what the string interpolation does, by simply joining `literals` and `expressions`:

```
const interpolated = interpolate`I paid ${10}€`
```

and this is how `interpolate` works:

```
function interpolate(literals, ...expressions) {
  let string = ``
  for (const [i, val] of expressions) {
    string += literals[i] + val
  }
  string += literals[literals.length - 1]
  return string
}
```

The Set Data Structure

A Set data structure allows to add data to a container, a collection of objects or primitive types (strings, numbers or booleans), and you can think of it as a Map where values are used as map keys, with the map value always being a boolean true.

What is a Set

A Set data structure allows to add data to a container.

ECMAScript 6 (also called ES2015) introduced the Set data structure to the JavaScript world, along with Map

A Set is a collection of objects or primitive types (strings, numbers or booleans), and you can think of it as a Map where values are used as map keys, with the map value always being a boolean true.

Initialize a Set

A Set is initialized by calling:

```
const s = new Set()
```

Add items to a Set

You can add items to the Set by using the `add` method:

```
s.add('one')
s.add('two')
```

A set only stores unique elements, so calling `s.add('one')` multiple times won't add new items.

Check if an item is in the set

Once an element is in the set, we can check if the set contains it:

```
s.has('one') //true
s.has('three') //false
```

Delete an item from a Set by key

Use the `delete()` method:

```
s.delete('one')
```

Determine the number of items in a Set

Use the `size` property:

```
s.size
```

Delete all items from a Set

Use the `clear()` method:

```
s.clear()
```

Iterate the items in a Set

Use the `keys()` or `values()` methods - they are equivalent:

```
for (const k of s.keys()) {
  console.log(k)
}

for (const k of s.values()) {
  console.log(k)
}
```

The `entries()` method returns an iterator, which you can use like this:

```
const i = s.entries()
console.log(i.next())
```

calling `i.next()` will return each element as a `{ value, done = false }` object until the iterator ends, at which point `done` is `true`.

You can also use the forEach() method on the set:

```
s.forEach(v => console.log(v))
```

or you can just use the set in a for..of loop:

```
for (const k of s) {
  console.log(k)
}
```

Initialize a Set with values

You can initialize a Set with a set of values:

```
const s = new Set([1, 2, 3, 4])
```

Convert to array

Convert the Set keys into an array

```
const a = [...s.keys()]

// or

const a = [...s.values()]
```

A WeakSet

A WeakSet is a special kind of Set.

In a Set, items are never garbage collected. A WeakSet instead lets all its items be freely garbage collected. Every key of a WeakSet is an object. When the reference to this object is lost, the value can be garbage collected.

Here are the main differences:

1. you cannot iterate over the WeakSet
2. you cannot clear all items from a WeakSet
3. you cannot check its size

A WeakSet is generally used by framework-level code, and only exposes these methods:

- add()
- has()
- delete()

The Map Data Structure

Discover the Map data structure introduced in ES6 to associate data with keys. Before its introduction, people generally used objects as maps, by associating some object or value to a specific key value

What is a Map

A Map data structure allows to associate data to a key.

Before ES6

ECMAScript 6 (also called ES2015) introduced the Map data structure to the JavaScript world, along with Set

Before its introduction, people generally used objects as maps, by associating some object or value to a specific key value:

```
const car = {}
car['color'] = 'red'
car.owner = 'Flavio'
console.log(car['color']) //red
console.log(car.color) //red
console.log(car.owner) //Flavio
console.log(car['owner']) //Flavio
```

Enter Map

ES6 introduced the Map data structure, providing us a proper tool to handle this kind of data organization.

A Map is initialized by calling:

```
const m = new Map()
```

Add items to a Map

You can add items to the map by using the `set` method:

```
m.set('color', 'red')
m.set('age', 2)
```

Get an item from a map by key

And you can get items out of a map by using `get`:

```
const color = m.get('color')
const age = m.get('age')
```

Delete an item from a map by key

Use the `delete()` method:

```
m.delete('color')
```

Delete all items from a map

Use the `clear()` method:

```
m.clear()
```

Check if a map contains an item by key

Use the `has()` method:

```
const hasColor = m.has('color')
```

Find the number of items in a map

Use the `size` property:

```
const size = m.size
```

Initialize a map with values

You can initialize a map with a set of values:

```
const m = new Map([['color', 'red'], ['owner', 'Flavio'], ['age', 2]])
```

Map keys

Just like any value (object, array, string, number) can be used as the value of the key-value entry of a map item, **any value can be used as the key**, even objects.

If you try to get a non-existing key using `get()` out of a map, it will return `undefined`.

Weird situations you'll almost never find in real life

```
const m = new Map()
m.set(NaN, 'test')
m.get(NaN) //test
```

```
const m = new Map()
m.set(+0, 'test')
m.get(-0) //test
```

Iterating over a map

Iterate over map keys

Map offers the `keys()` method we can use to iterate on all the keys:

```
for (const k of m.keys()) {
  console.log(k)
}
```

Iterate over map values

Map offers the `values()` method we can use to iterate on all the values:

```
for (const v of m.values()) {
  console.log(v)
}
```

Iterate over map key, value pairs

Map offers the `values()` method we can use to iterate on all the values:

```
for (const [k, v] of m.entries()) {
  console.log(k, v)
}
```

which can be simplified to

```
for (const [k, v] of m) {
  console.log(k, v)
}
```

Convert to array

Convert the map keys into an array

```
const a = [...m.keys()]
```

Convert the map values into an array

```
const a = [...m.values()]
```

WeakMap

A WeakMap is a special kind of map.

In a Map, items are never garbage collected. A WeakMap instead lets all its items be freely garbage collected. Every key of a WeakMap is an object. When the reference to this object is lost, the value can be garbage collected.

Here are the main differences:

1. you cannot iterate over the keys or values (or key-values) of a WeakMap
2. you cannot clear all items from a WeakMap
3. you cannot check its size

A WeakMap exposes those methods, which are equivalent to the Map ones:

- `get(k)`
- `set(k, v)`
- `has(k)`
- `delete(k)`

The use cases of a WeakMap are less evident than the ones of a Map, and you might never find the need for them, but essentially it can be used to build a memory-sensitive cache that is not going to interfere with garbage collection, or for careful encapsualtion and information hiding.

Loops and Scope

There is one feature of JavaScript that might cause a few headaches to developers, related to loops and scoping. Learn some tricks about loops and scoping with var and let

There is one feature of JavaScript that might cause a few headaches to developers, related to loops and scoping.

Take this example:

```
const operations = []

for (var i = 0; i < 5; i++) {
  operations.push(() => {
    console.log(i)
  })
}

for (const operation of operations) {
  operation()
}
```

It basically iterates and for 5 times it adds a function to an array called operations. This function simply console logs the loop index variable `i`.

Later it runs these functions.

The expected result here should be:

```
0
1
2
3
4
```

but actually what happens is this:

```
5
5
5
5
5
```

Why is this the case? Because of the use of `var`.

Since `var` declarations are **hoisted**, the above code equals to

```
var i;
const operations = []

for (i = 0; i < 5; i++) {
  operations.push(() => {
    console.log(i)
  })
}

for (const operation of operations) {
  operation()
}
```

so, in the for-of loop, `i` is still visible, it's equal to 5 and every reference to `i` in the function is going to use this value.

So how should we do to make things work as we want?

The simplest solution is to use `let` declarations. Introduced in ES2015, they are a great help in avoiding some of the weird things about `var` declarations.

Simply changing `var` to `let` in the loop variable is going to work fine:

```
const operations = []

for (let i = 0; i < 5; i++) {
  operations.push(() => {
    console.log(i)
  })
}

for (const operation of operations) {
  operation()
}
```

Here's the output:

```
0
1
2
3
4
```

How is this possible? This works because on every loop iteration `i` is created as a new variable each time, and every function added to the `operations` array gets its own copy of `i`.

Keep in mind you cannot use `const` in this case, because there would be an error as `for` tries to assign a new value in the second iteration.

Another way to solve this problem was very common in pre-ES6 code, and it is called **Immediately Invoked Function Expression** (IIFE).

In this case you can wrap the entire function and bind `i` to it. Since in this way you're creating a function that immediately executes, you return a new function from it, so we can execute it later:

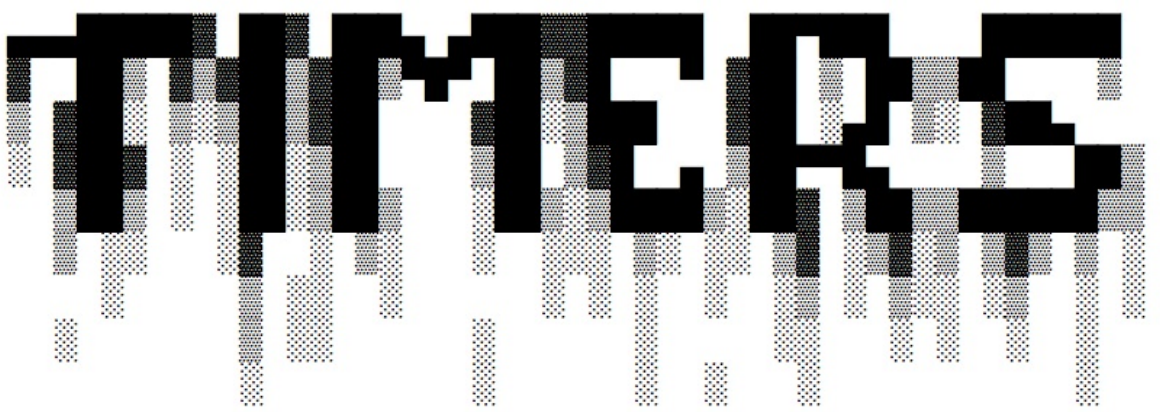
```
const operations = []

for (var i = 0; i < 5; i++) {
  operations.push(((j) => {
    return () => console.log(j)
  })(i))
}

for (const operation of operations) {
  operation()
}
```

Timers

When writing JavaScript code, you might want to delay the execution of a function. Learn how to use setTimeout and setInterval to schedule functions in the future



`setTimeout()`

When writing JavaScript code, you might want to delay the execution of a function.

This is the job of `setTimeout`. You specify a callback function to execute later, and a value expressing how later you want it to run, in milliseconds:

```
setTimeout(() => {
  // runs after 2 seconds
}, 2000)

setTimeout(() => {
  // runs after 50 milliseconds
}, 50)
```

This syntax defines a new function. You can call whatever other function you want in there, or you can pass an existing function name, and a set of parameters:

```
const myFunction = (firstParam, secondParam) => {
```

```
  // do something
}

// runs after 2 seconds
setTimeout(myFunction, 2000, firstParam, secondParam)
```

`setTimeout` returns the timer id. This is generally not used, but you can store this id, and clear it if you want to delete this scheduled function execution:

```
const id = setTimeout(() => {
  // should run after 2 seconds
}, 2000)

// I changed my mind
clearTimeout(id)
```

Zero delay

If you specify the timeout delay to `0`, the callback function will be executed as soon as possible, but after the current function execution:

```
setTimeout(() => {
  console.log('after ')
}, 0)

console.log(' before ')
```

will print `before after`.

This is especially useful to avoid blocking the CPU on intensive tasks, and let other functions be executed while performing a heavy calculation, by queuing functions in the scheduler.

> Some browsers (IE and Edge) implement a `setImmediate()` method that does this same exact functionality, but it's not standard and unavailable on other browsers. But it's a standard function in Node.js.

`setInterval()`

`setInterval` is a function similar to `setTimeout`, with a difference: instead of running the callback function once, it will run it forever, at the specific time interval you specify (in milliseconds):

```
setInterval(() => {
  // runs every 2 seconds
}, 2000)
```

The function above runs every 2 seconds unless you tell it to stop, using `clearInterval`, passing it the interval id that `setInterval` returned:

```
const id = setInterval(() => {
  // runs every 2 seconds
}, 2000)

clearInterval(id)
```

It's common to call `clearInterval` inside the setInterval callback function, to let it auto-determine if it should run again or stop. For example this code runs something unless App.somethingIWait has the value `arrived`:

```
const interval = setInterval(function() {
  if (App.somethingIWait === 'arrived') {
    clearInterval(interval)

    // otherwise do things
  }
}, 100)
```

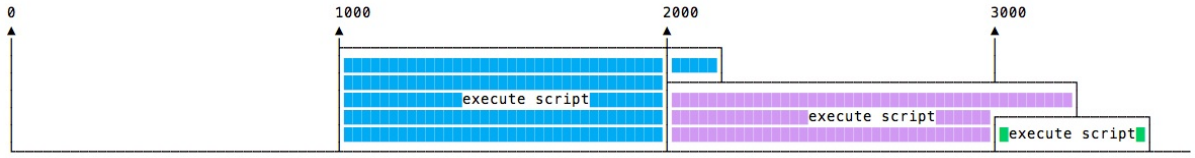
Recursive setTimeout

`setInterval` starts a function every n milliseconds, without any consideration about when a function finished its execution.

If a function takes always the same amount of time, it's all fine:

Maybe the function takes different execution times, depending on network conditions for example:

And maybe one long execution overlaps the next one:



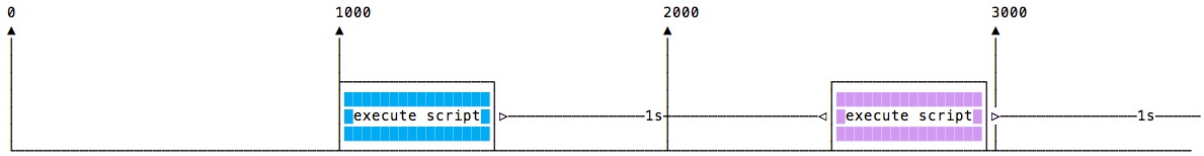
To avoid this, you can schedule a recursive setTimeout to be called when the callback function finishes:

```
const myFunction = () => {
  // do something

  setTimeout(myFunction, 1000)
}

setTimeout(
  myFunction()
}, 1000)
```

to achieve this scenario:



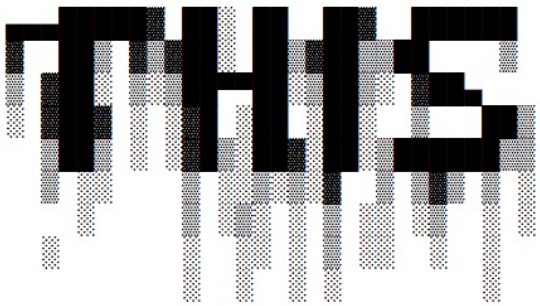
Node.js

`setTimeout` and `setInterval` are also available in Node.js, through the Timers module.

Node.js also provides `setImmediate()`, which is equivalent to using `setTimeout(() => {}, 0)`, mostly used to work with the Node.js Event Loop.

this in JavaScript

`this` is a value that has different values depending on where it's used. Not knowing this tiny detail of JavaScript can cause a lot of headaches, so it's worth taking 5 minutes to learn all the tricks



`this` is a value that has different values depending on where it's used.

Not knowing this tiny detail of JavaScript can cause a lot of headaches, so it's worth taking 5 minutes to learn all the tricks.

`this` in strict mode

Outside any object, `this` in **strict mode** is always `undefined`.

Notice I mentioned strict mode. If strict mode is disabled (the default state if you don't explicitly add `'use strict'` on top of your file), you are in the so-called *sloppy mode*, and `this` - unless some specific cases mentioned here below - has the value of the global object.

Which means `window` in a browser context.

`this` in methods

A method is a function attached to an object.

You can see it in various forms.

Here's one:

```
const car = {
  maker: 'Ford',
  model: 'Fiesta',

  drive() {
    console.log(`Driving a ${this.maker} ${this.model} car!`)
  }
}

car.drive()
//Driving a Ford Fiesta car!
```

In this case, using a regular function, `this` is automatically bound to the object.

Note: the above method declaration is the same as `drive: function() {` ..., but shorter:

```
const car = {
  maker: 'Ford',
  model: 'Fiesta',

  drive: function() {
    console.log(`Driving a ${this.maker} ${this.model} car!`)
  }
}
```

The same works in this example:

```
const car = {
  maker: 'Ford',
  model: 'Fiesta'
}

car.drive = function() {
  console.log(`Driving a ${this.maker} ${this.model} car!`)
}

car.drive()
//Driving a Ford Fiesta car!
```

An arrow function does not work in the same way, as it's lexically bound:

```
const car = {
  maker: 'Ford',
  model: 'Fiesta',

  drive: () => {
    console.log(`Driving a ${this.maker} ${this.model} car!`)
  }
}
```

```
car.drive()
//Driving a undefined undefined car!
```

Binding arrow functions

You cannot bind a value to an arrow function, like you do with normal functions.

It's simply not possible due to the way they work. `this` is **lexically bound**, which means its value is derived from the context where they are defined.

Explicitly pass an object to be used as `this`

JavaScript offers a few ways to map `this` to any object you want.

Using `bind()`, at the **function declaration** step:

```
const car = {
  maker: 'Ford',
  model: 'Fiesta'
}

const drive = function() {
  console.log(`Driving a ${this.maker} ${this.model} car!`)
}.bind(car)

drive()
//Driving a Ford Fiesta car!
```

You could also bind an existing object method to remap its `this` value:

```
const car = {
  maker: 'Ford',
  model: 'Fiesta',

  drive() {
    console.log(`Driving a ${this.maker} ${this.model} car!`)
  }
}

const anotherCar = {
  maker: 'Audi',
  model: 'A4'
}

car.drive.bind(anotherCar)()
//Driving a Audi A4 car!
```

Using `call()` or `apply()`, at the **function invocation** step:

```
const car = {
  maker: 'Ford',
  model: 'Fiesta'
}

const drive = function(kmh) {
  console.log(`Driving a ${this.maker} ${this.model} car at ${kmh} km/h!`)
}

drive.call(car, 100)
//Driving a Ford Fiesta car at 100 km/h!

drive.apply(car, [100])
//Driving a Ford Fiesta car at 100 km/h!
```

The first parameter you pass to `call()` or `apply()` is always bound to `this`. The difference between call() and apply() is just that the second one wants an array as the arguments list, while the first accepts a variable number of parameters, which passes as function arguments.

The special case of browser event handlers

In event handlers callbacks, `this` refers to the HTML element that received the event:

```
document.querySelector('#button').addEventListener('click', function(e) {
  console.log(this) //HTMLElement
}
```

You can bind it using

```
document.querySelector('#button').addEventListener(
  'click',
  function(e) {
    console.log(this) //Window if global, or your context
  }.bind(this)
)
```

JavaScript Strict Mode

Strict Mode is an ES5 feature, and it's a way to make JavaScript behave in a better way. And in a different way, as enabling Strict Mode changes the semantics of the JavaScript language. It's really important to know the main differences between JavaScript code in strict mode, and normal JavaScript, which is often referred as sloppy mode

Strict Mode is an ES5 feature, and it's a way to make JavaScript behave in a **better way**.

And in a **different way**, as enabling Strict Mode changes the semantics of the JavaScript language.

It's really important to know the main differences between JavaScript code in strict mode, and "normal" JavaScript, which is often referred as **sloppy mode**.

Strict Mode mostly removes functionality that was possible in ES3, and deprecated since ES5 (but not removed because of backwards compatibility requirements)

How to enable Strict Mode

Strict mode is optional. As with every breaking change in JavaScript, we can't simply change how the language behaves by default, because that would break gazillions of JavaScript around, and JavaScript puts a lot of effort into making sure 1996 JavaScript code still works today. It's a key of its success.

So we have the `'use strict'` directive we need to use to enable Strict Mode.

You can put it at the beginning of a file, to apply it to all the code contained in the file:

```
'use strict'

const name = 'Flavio'
const hello = () => 'hey'

//...
```

You can also enable Strict Mode for an individual function, by putting `'use strict'` at the beginning of the function body:

```
function hello() {
  'use strict'

  return 'hey'
}
```

This is useful when operating on legacy code, where you don't have the time to test or the confidence to enable strict mode on the whole file.

What changes in Strict Mode

Accidental global variables

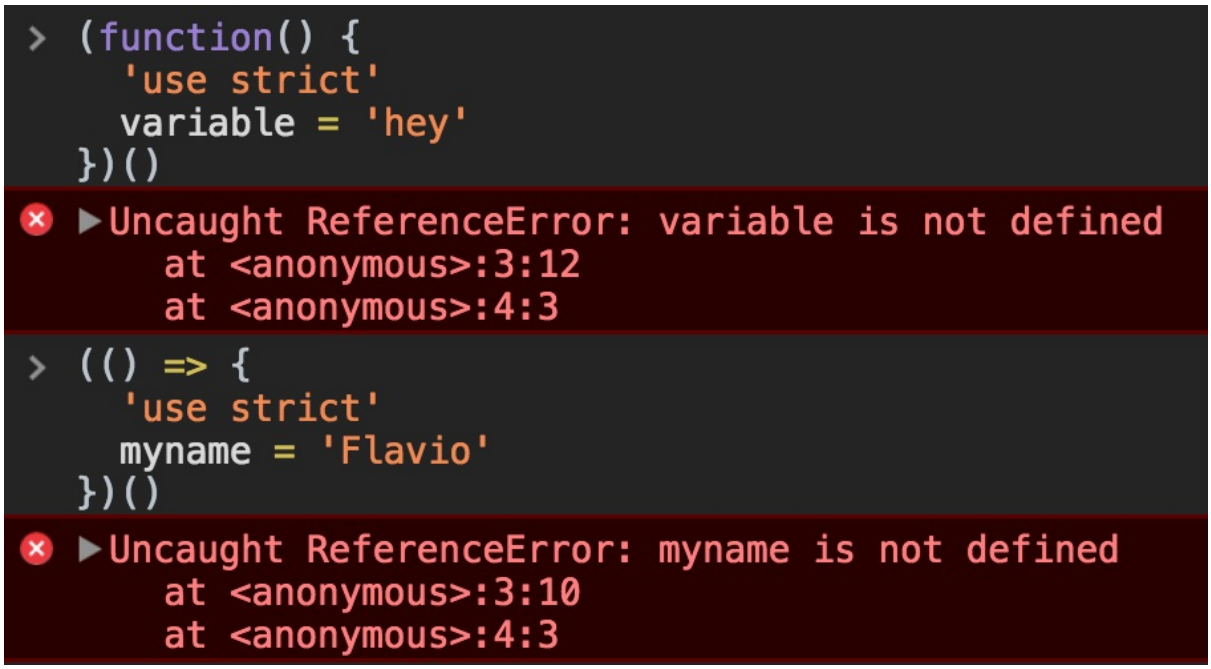
If you assign a value to an undeclared variable, JavaScript by default creates that variable on the global object:

```
;(function() {
  variable = 'hey'
})()(() => {
  name = 'Flavio'
})()

variable //'hey'
name //'Flavio'
```

Turning on Strict Mode, an error is raised if you try to do what we did above:

```
;(function() {
  'use strict'
  variable = 'hey'
})()(() => {
  'use strict'
  myname = 'Flavio'
})()
```

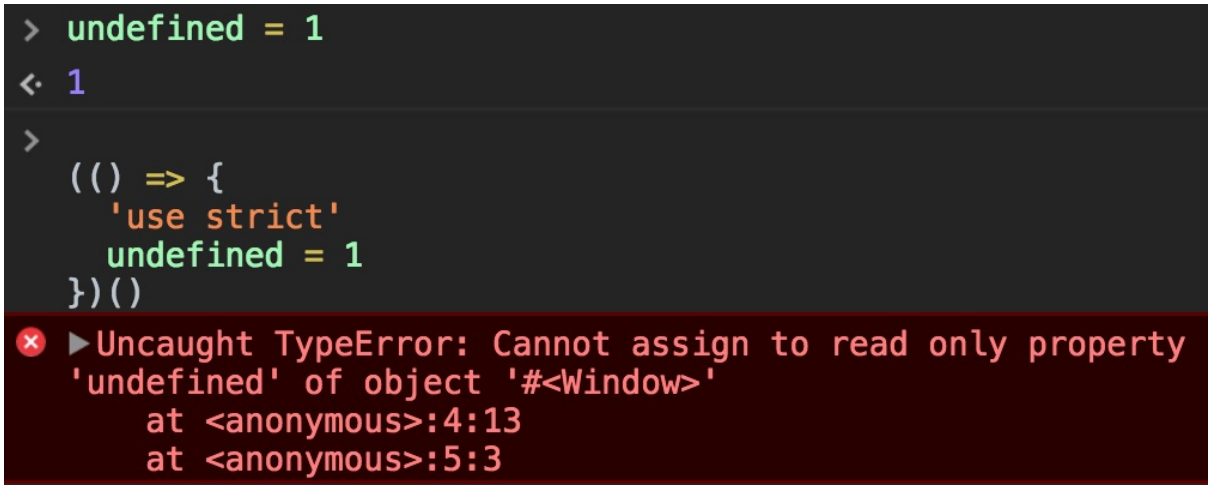


Assignment errors

JavaScript silently fails some conversion errors.

In Strict Mode, those silent errors now raise issues:

```
const undefined = 1(() => {
  'use strict'
  undefined = 1
})()
```

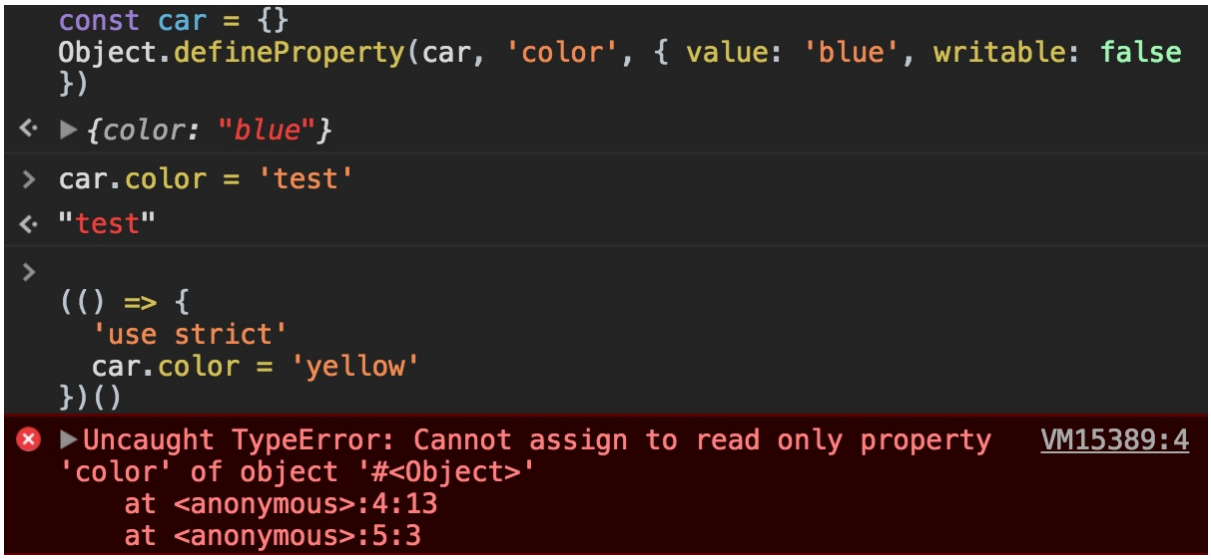


The same applies to Infinity, NaN, `eval`, `arguments` and more.

In JavaScript you can define a property of an object to be not writable, by using

```
const car = {}
Object.defineProperty(car, 'color', { value: 'blue', writable: false })
```

In strict mode, you can't override this value, while in sloppy mode that's possible:



The same works for getters:

```
const car = {
  get color() {
    return 'blue'
  }
}
car.color = 'red'(
  //ok

  () => {
    'use strict'
```

```
    car.color = 'yellow' //TypeError: Cannot set property color of #<Object> which has onl
y a getter
  }
)()
```

Sloppy mode allows to extend a non-extensible object:

```
const car = { color: 'blue' }
Object.preventExtensions(car)
car.model = 'Fiesta'(
  //ok

  () => {
    'use strict'
    car.owner = 'Flavio' //TypeError: Cannot add property owner, object is not extensible
  }
)()
```

Also, sloppy mode allows to set properties on primitive values, without failing, but also without doing nothing at all:

```
true.false = ''(
  //''
  1
).name =
  'xxx' //'xxx'
var test = 'test' //undefined
test.testing = true //true
test.testing //undefined
```

Strict mode fails in all those cases:

```
;(() => {
  'use strict'
  true.false = ''(
    //TypeError: Cannot create property 'false' on boolean 'true'
    1
  ).name =
    'xxx' //TypeError: Cannot create property 'name' on number '1'
  'test'.testing = true //TypeError: Cannot create property 'testing' on string 'test'
})()
```

Deletion errors

In sloppy mode, if you try to delete a property that you cannot delete, JavaScript simply returns false, while in Strict Mode, it raises a TypeError:

```
delete Object.prototype(
```

```
  //false

  () => {
    'use strict'
    delete Object.prototype //TypeError: Cannot delete property 'prototype' of function Ob
ject() { [native code] }
  }
)()
```

Function arguments with the same name

In normal functions, you can have duplicate parameter names:

```
(function(a, a, b) {
  console.log(a, b)
})(1, 2, 3)
//2 3


(function(a, a, b) {
  'use strict'
  console.log(a, b)
})(1, 2, 3)
//Uncaught SyntaxError: Duplicate parameter name not allowed in this context
```

Note that arrow functions always raise a `SyntaxError` in this case:

```
((a, a, b) => {
  console.log(a, b)
})(1, 2, 3)
//Uncaught SyntaxError: Duplicate parameter name not allowed in this context
```

Octal syntax

Octal syntax in Strict Mode is disabled. By default, prepending a `0` to a number compatible with the octal numeric format makes it (sometimes confusingly) interpreted as an octal number:

```
(() => {
  console.log(010)
})()
//8

(() => {
  'use strict'
  console.log(010)
})()
//Uncaught SyntaxError: Octal literals are not allowed in strict mode.
```

You can still enable octal numbers in Strict Mode using the `0oXX` syntax:

```
;(() => {
  'use strict'
  console.log(0o10)
})()
//8
```

Removed `with`

Strict Mode disables the `with` keyword, to remove some edge cases and allow more optimization at the compiler level.

JavaScript Immediately-invoked Function Expressions (IIFE)

An Immediately-invoked Function Expression is a way to execute functions immediately, as soon as they are created. IIFEs are very useful because they don't pollute the global object, and they are a simple way to isolate variables declarations

An **Immediately-invoked Function Expression** (IIFE for friends) is a way to execute functions immediately, as soon as they are created.

IIFEs are very useful because **they don't pollute the global object**, and they are a simple way to **isolate variables declarations**.

This is the syntax that defines an IIFE:

```
;(function() {
  /* */
})()
```

IIFEs can be defined with arrow functions as well:

```
;(() => {
  /* */
})()
```

We basically have a function defined inside parentheses, and then we append `()` to execute that function: `(/* function */)()`.

Those wrapping parentheses are actually what make our function, internally, be considered an expression. Otherwise, the function declaration would be invalid, because we didn't specify any name:

```
>> function() {
     /* */
   }
SyntaxError: function statement requires a name [Learn More]
>> (function() {
     /* */
   })()
<- undefined
```

Function declarations want a name, while function expressions do not require it.

You could also put the invoking parentheses *inside* the expression parentheses, there is no difference, just a styling preference:

```
(function() {
  /* */
}())

(() => {
  /* */
}())
```

Alternative syntax using unary operators

There is some weirder syntax that you can use to create an IIFE, but it's very rarely used in the real world, and it relies on using *any* unary operator:

```
;-(function() {
  /* */
})() +
  (function() {
    /* */
  })()
```

```
~(function() {
  /* */
})()

!(function() {
  /* */
})()
```

(does not work with arrow functions)

Named IIFE

An IIFE can also be named regular functions (not arrow functions). This does not change the fact that the function does not "leak" to the global scope, and it cannot be invoked again after its execution:

```
;(function doSomething() {
  /* */
})()
```

IIFEs starting with a semicolon

You might see this in the wild:

```
;(function() {
  /* */
})()
```

This prevents issues when blindly concatenating two JavaScript files. Since JavaScript does not require semicolons, you might concatenate with a file with some statements in its last line that causes a syntax error.

This problem is essentially solved with "smart" code bundlers like webpack.

Async and Await

Discover the modern approach to asynchronous functions in JavaScript. JavaScript evolved in a very short time from callbacks to Promises, and since ES2017 asynchronous JavaScript is even simpler with the async/await syntax

Introduction

JavaScript evolved in a very short time from callbacks to promises (ES2015), and since ES2017 asynchronous JavaScript is even simpler with the async/await syntax.

Async functions are a combination of promises and generators, and basically they are a higher level abstraction over promises. Let me repeat: **async/await is built on promises**.

Why were async/await introduced?

They reduce the boilerplate around promises, and the "don't break the chain" limitation of chaining promises.

When Promises were introduced in ES2015, they were meant to solve a problem with asynchronous code, and they did, but over the 2 years that separated ES2015 and ES2017, it was clear that *promises could not be the final solution*.

Promises were introduced to solve the famous *callback hell* problem, but they introduced complexity on their own, and syntax complexity.

They were good primitives around which a better syntax could be exposed to the developers, so when the time was right we got **async functions**.

They make the code look like it's synchronous, but it's asynchronous and non-blocking behind the scenes.

How it works

An async function returns a promise, like in this example:

```
const doSomethingAsync = () => {
    return new Promise((resolve) => {
        setTimeout(() => resolve('I did something'), 3000)
    })
}
```

When you want to **call** this function you prepend `await`, and **the calling code will stop until the promise is resolved or rejected**. One caveat: the client function must be defined as `async`. Here's an example:

```
const doSomething = async () => {
    console.log(await doSomethingAsync())
}
```

A quick example

This is a simple example of async/await used to run a function asynchronously:

```
const doSomethingAsync = () => {
    return new Promise((resolve) => {
        setTimeout(() => resolve('I did something'), 3000)
    })
}

const doSomething = async () => {
    console.log(await doSomethingAsync())
}

console.log('Before')
doSomething()
console.log('After')
```

The above code will print the following to the browser console:

```
Before
After
I did something //after 3s
```

Promise all the things

Prepending the `async` keyword to any function means that the function will return a promise.

Even if it's not doing so explicitly, it will internally make it return a promise.

This is why this code is valid:

```
const aFunction = async () => {
  return 'test'
}

aFunction().then(alert) // This will alert 'test'
```

and it's the same as:

```
const aFunction = async () => {
  return Promise.resolve('test')
}

aFunction().then(alert) // This will alert 'test'
```

The code is much simpler to read

As you can see in the example above, our code looks very simple. Compare it to code using plain promises, with chaining and callback functions.

And this is a very simple example, the major benefits will arise when the code is much more complex.

For example here's how you would get a JSON resource, and parse it, using promises:

```
const getFirstUserData = () => {
  return fetch('/users.json') // get users list
    .then(response => response.json()) // parse JSON
    .then(users => users[0]) // pick first user
    .then(user => fetch(`/users/${user.name}`)) // get user data
    .then(userResponse => response.json()) // parse JSON
}

getFirstUserData()
```

And here is the same functionality provided using await/async:

```
const getFirstUserData = async () => {
  const response = await fetch('/users.json') // get users list
  const users = await response.json() // parse JSON
  const user = users[0] // pick first user
  const userResponse = await fetch(`/users/${user.name}`) // get user data
```

```
  const userData = await user.json() // parse JSON
  return userData
}

getFirstUserData()
```

Multiple async functions in series

Async functions can be chained very easily, and the syntax is much more readable than with plain promises:

```
const promiseToDoSomething = () => {
    return new Promise(resolve => {
        setTimeout(() => resolve('I did something'), 10000)
    })
}

const watchOverSomeoneDoingSomething = async () => {
    const something = await promiseToDoSomething()
    return something + ' and I watched'
}

const watchOverSomeoneWatchingSomeoneDoingSomething = async () => {
    const something = await watchOverSomeoneDoingSomething()
    return something + ' and I watched as well'
}

watchOverSomeoneWatchingSomeoneDoingSomething().then((res) => {
    console.log(res)
})
```

Will print:

```
I did something and I watched and I watched as well
```

Easier debugging

Debugging promises is hard because the debugger will not step over asynchronous code.

Async/await makes this very easy, because to the compiler it's just like synchronous code.

Dates in JavaScript

Working with dates in JavaScript can be complicated. Learn all the quirks and how to use them.

Introduction

Working with dates can be *complicated*. No matter the technology, developers do feel the pain.

JavaScript offers us a date handling functionality through a powerful object: `Date`.

> This article does *not* talk about **Moment.js**, which I believe it's the best library out there to handle dates, and you should almost always use that when working with dates.

The Date object

A Date object instance represents a single point in time.

Despite being named `Date`, it also handles **time**.

Initialize the Date object

We initialize a Date object by using

```
new Date()
```

This creates a Date object pointing to the current moment in time.

Internally, dates are expressed in milliseconds since Jan 1st 1970 (UTC). This date is important because as far as computers are concerned, that's where it all began.

You might be familiar with the UNIX timestamp: that represents the number of *seconds* that passed since that famous date.

> Important: the UNIX timestamp reasons in seconds. JavaScript dates reason in milliseconds.

If we have a UNIX timestamp, we can instantiate a JavaScript Date object by using

```
const timestamp = 1530826365
new Date(timestamp * 1000)
```

If we pass 0 we'd get a Date object that represents the time at Jan 1st 1970 (UTC):

```
new Date(0)
```

If we pass a string rather than a number, then the Date object uses the `parse` method to determine which date you are passing. Examples:

```
new Date('2018-07-22')
new Date('2018-07') //July 1st 2018, 00:00:00
new Date('2018') //Jan 1st 2018, 00:00:00
new Date('07/22/2018')
new Date('2018/07/22')
new Date('2018/7/22')
new Date('July 22, 2018')
new Date('July 22, 2018 07:22:13')
new Date('2018-07-22 07:22:13')
new Date('2018-07-22T07:22:13')
new Date('25 March 2018')
new Date('25 Mar 2018')
new Date('25 March, 2018')
new Date('March 25, 2018')
new Date('March 25 2018')
new Date('March 2018') //Mar 1st 2018, 00:00:00
new Date('2018 March') //Mar 1st 2018, 00:00:00
new Date('2018 MARCH') //Mar 1st 2018, 00:00:00
new Date('2018 march') //Mar 1st 2018, 00:00:00
```

There's lots of flexibility here. You can add, or omit, the leading zero in months or days.

Be careful with the month/day position, or you might end up with the month being misinterpreted as the day.

You can also use `Date.parse`:

```
Date.parse('2018-07-22')
Date.parse('2018-07') //July 1st 2018, 00:00:00
Date.parse('2018') //Jan 1st 2018, 00:00:00
Date.parse('07/22/2018')
```

```
Date.parse('2018/07/22')
Date.parse('2018/7/22')
Date.parse('July 22, 2018')
Date.parse('July 22, 2018 07:22:13')
Date.parse('2018-07-22 07:22:13')
Date.parse('2018-07-22T07:22:13')
```

`Date.parse` will return a timestamp (in milliseconds) rather than a Date object.

You can also pass a set of ordered values that represent each part of a date: the year, the month (starting from 0), the day, the hour, the minutes, seconds and milliseconds:

```
new Date(2018, 6, 22, 7, 22, 13, 0)
new Date(2018, 6, 22)
```

The minimum should be 3 parameters, but most JavaScript engines also interpret less than these:

```
new Date(2018, 6) //Sun Jul 01 2018 00:00:00 GMT+0200 (Central European Summer Time)
new Date(2018) //Thu Jan 01 1970 01:00:02 GMT+0100 (Central European Standard Time)
```

In any of these cases, the resulting date is relative to the timezone of your computer. This means that **two different computers might output a different value for the same date object**.

JavaScript, without any information about the timezone, will consider the date as UTC, and will automatically perform a conversion to the current computer timezone.

So, summarizing, you can create a new Date object in 4 ways

- passing **no parameters**, creates a Date object that represents "now"
- passing a **number**, which represents the milliseconds from 1 Jan 1970 00:00 GMT
- passing a **string**, which represents a date
- passing a **set of parameters**, which represent the different parts of a date

Timezones

When initializing a date you can pass a timezone, so the date is not assumed UTC and then converted to your local timezone.

You can specify a timezone by adding it in +HOURS format, or by adding the timezone name wrapped in parentheses:

```
new Date('July 22, 2018 07:22:13 +0700')
```

```
new Date('July 22, 2018 07:22:13 (CET)')
```

If you specify a wrong timezone name in the parentheses, JavaScript will default to UTC without complaining.

If you specify a wrong numeric format, JavaScript will complain with an "Invalid Date" error.

Date conversions and formatting

Given a Date object, there are lots of methods that will generate a string from that date:

```
const date = new Date('July 22, 2018 07:22:13')

date.toString() // "Sun Jul 22 2018 07:22:13 GMT+0200 (Central European Summer Time)"
date.toTimeString() //"07:22:13 GMT+0200 (Central European Summer Time)"
date.toUTCString() //"Sun, 22 Jul 2018 05:22:13 GMT"
date.toDateString() //"Sun Jul 22 2018"
date.toISOString() //"2018-07-22T05:22:13.000Z" (ISO 8601 format)
date.toLocaleString() //"22/07/2018, 07:22:13"
date.toLocaleTimeString()    //"07:22:13"
date.getTime() //1532236933000
date.getTime() //1532236933000
```

The Date object getter methods

A Date object offers several methods to check its value. These all depends on the current timezone of the computer:

```
const date = new Date('July 22, 2018 07:22:13')

date.getDate() //22
date.getDay() //0 (0 means sunday, 1 means monday..)
date.getFullYear() //2018
date.getMonth() //6 (starts from 0)
date.getHours() //7
date.getMinutes() //22
date.getSeconds() //13
date.getMilliseconds() //0 (not specified)
date.getTime() //1532236933000
date.getTimezoneOffset() //-120 (will vary depending on where you are and when you check -
 this is CET during the summer). Returns the timezone difference expressed in minutes
```

There are equivalent UTC versions of these methods, that return the UTC value rather than the values adapted to your current timezone:

```
date.getUTCDate() //22
```

```
date.getUTCDay() //0 (0 means sunday, 1 means monday..)
date.getUTCFullYear() //2018
date.getUTCMonth() //6 (starts from 0)
date.getUTCHours() //5 (not 7 like above)
date.getUTCMinutes() //22
date.getUTCSeconds() //13
date.getUTCMilliseconds() //0 (not specified)
```

Editing a date

A Date object offers several methods to edit a date value:

```
const date = new Date('July 22, 2018 07:22:13')

date.setDate(newValue)
date.setDay(newValue)
date.setFullYear(newValue) //note: avoid setYear(), it's deprecated
date.setMonth(newValue)
date.setHours(newValue)
date.setMinutes(newValue)
date.setSeconds(newValue)
date.setMilliseconds(newValue)
date.setTime(newValue)
date.setTimezoneOffset(newValue)
```

> `setDay` and `setMonth` start numbering from 0, so for example March is month 2.

Fun fact: those methods "overlap", so if you, for example, set `date.setHours(48)`, it will increment the day as well.

Good to know: you can add more than one parameter to `setHours()` to also set minutes, seconds and milliseconds: `setHours(0, 0, 0, 0)` - the same applies to `setMinutes` and `setSeconds`.

As for get, *also set* methods have an UTC equivalent:

```
const date = new Date('July 22, 2018 07:22:13')

date.setUTCDate(newalue)
date.setUTCDay(newValue)
date.setUTCFullYear(newValue)
date.setUTCMonth(newValue)
date.setUTCHours(newValue)
date.setUTCMinutes(newValue)
date.setUTCSeconds(newValue)
date.setUTCMilliseconds(newValue)
```

Get the current timestamp

If you want to get the current timestamp in milliseconds, you can use the shorthand

```
Date.now()
```

instead of

```
new Date().getTime()
```

JavaScript tries hard to work fine

Pay attention. If you overflow a month with the days count, there will be no error, and the date will go to the next month:

```
new Date(2018, 6, 40) //Thu Aug 09 2018 00:00:00 GMT+0200 (Central European Summer Time)
```

The same goes for months, hours, minutes, seconds and milliseconds.

Format dates according to the locale

The Internationalization API, well supported in modern browsers (notable exception: UC Browser), allows you to translate dates.

It's exposed by the `Intl` object, which also helps localizing numbers, strings and currencies.

We're interested in `Intl.DateTimeFormat()`.

Here's how to use it.

Format a date according to the computer default locale:

```
// "12/22/2017"
const date = new Date('July 22, 2018 07:22:13')
new Intl.DateTimeFormat().format(date) //"22/07/2018" in my locale
```

Format a date according to a different locale:

```
new Intl.DateTimeFormat('en-US').format(date) //"7/22/2018"
```

`Intl.DateTimeFormat` method takes an optional parameter that lets you customize the output. To also display hours, minutes and seconds:

```
const options = {
  year: 'numeric',
  month: 'numeric',
  day: 'numeric',
  hour: 'numeric',
  minute: 'numeric',
  second: 'numeric'
}

new Intl.DateTimeFormat('en-US', options).format(date) //"7/22/2018, 7:22:13 AM"
new Intl.DateTimeFormat('it-IT', options2).format(date) //"22/7/2018, 07:22:13"
```

Here's a reference of all the properties you can use.

Compare two dates

You can calculate the difference between two dates using `Date.getTime()`:

```
const date1 = new Date('July 10, 2018 07:22:13')
const date2 = new Date('July 22, 2018 07:22:13')
const diff = date2.getTime() - date1.getTime() //difference in milliseconds
```

In the same way you can check if two dates are equal:

```
const date1 = new Date('July 10, 2018 07:22:13')
const date2 = new Date('July 10, 2018 07:22:13')
if (date2.getTime() === date1.getTime()) {
  //dates are equal
}
```

Keep in mind that getTime() returns the number of milliseconds, so you need to factor in time in the comparison. `July 10, 2018 07:22:13` is **not** equal to new `July 10, 2018`. In this case you can use `setHours(0, 0, 0, 0)` to reset the time.

Math operators

Performing math operations and calculus is a very common thing to do with any programming language. JavaScript offers several operators to help us work with numbers

Performing math operations and calculus is a very common thing to do with any programming language.

JavaScript offers several operators to help us work with numbers.

Operators

Arithmetic operators

Addition (+)

```
const three = 1 + 2
const four = three + 1
```

The `+` operator also serves as string concatenation if you use strings, so pay attention:

```
const three = 1 + 2
three + 1 // 4
'three' + 1 // three1
```

Subtraction (-)

```
const two = 4 - 2
```

Division (/)

Returns the quotient of the first operator and the second:

```
const result = 20 / 5 //result === 4
const result = 20 / 7 //result === 2.857142857142857
```

If you divide by zero, JavaScript does not raise any error but returns the `Infinity` value (or `-Infinity` if the value is negative).

```
1 / 0 //Infinity
-1 / 0 //-Infinity
```

Remainder (%)

The remainder is a very useful calculation in many use cases:

```
const result = 20 % 5 //result === 0
const result = 20 % 7 //result === 6
```

A reminder by zero is always `NaN`, a special value that means "Not a Number":

```
1 % 0 //NaN
-1 % 0 //NaN
```

Multiplication (*)

```
1 * 2 //2
-1 * 2 //-2
```

Exponentiation (**)

Raise the first operand to the power second operand

```
1 ** 2 //1
2 ** 1 //2
2 ** 2 //4
2 ** 8 //256
8 ** 2 //64
```

Unary operators

Increment (++)

Increment a number. This is a unary operator, and if put before the number, it returns the value incremented.

If put after the number, it returns the original value, then increments it.

```
let x = 0
x++ //0
x //1
++x //2
```

Decrement (--)

Works like the increment operator, except it decrements the value.

```
let x = 0
x-- //0
x //-1
--x //-2
```

Unary negation (-)

Return the negation of the operand

```
let x = 2
-x //-2
x //2
```

Unary plus (+)

If the operand is not a number, it tries to convert it. Otherwise if the operand is already a number, it does nothing.

```
let x = 2
+x //2

x = '2'
+x //2

x = '2a'
+x //NaN
```

Assignment shortcuts

The regular assignment operator, `=`, has several shortcuts for all the arithmetic operators which let you combine assignment, assigning to the first operand the result of the operations with the second operand.

They are:

- `+=` : addition assignment
- `-=` : subtraction assignment
- `*=` : multiplication assignment

- `/=` : division assignment
- `%=` : remainder assignment
- `**=` : exponentiation assignment

Examples:

```
const a = 0
a += 5 //a === 5
a -= 2 //a === 3
a *= 2 //a === 6
a /= 2 //a === 3
a %= 2 //a === 1
```

Precedence rules

Every complex statement will introduce precedence problems.

Take this:

```
const a = 1 * 2 + 5 / 2 % 2
```

The result is 2.5, but why? What operations are executed first, and which need to wait?

Some operations have more precedence than the others. The precedence rules are listed in this table:

Operator	Description
`-` `+` `++` `--`	unary operators, increment and decrement
`*` `/` `%`	multiply/divide
`+` `-`	addition/subtraction
`=` `+=` `-=` `*=` `/=` `%=` `**=`	assignments

Operations on the same level (like `+` and `-`) are executed in the order they are found

Following this table, we can solve this calculation:

```
const a = 1 * 2 + 5 / 2 % 2
const a = 1 * 2 + 5 / 2 % 2
const a = 2 + 2.5 % 2
const a = 2 + 0.5
const a = 2.5
```

The Math object

The Math object contains lots of utilities math-related. This tutorial describes them all

The Math object contains lots of utilities math-related.

It contains constants and functions.

Constants

Item	Description
`Math.E`	The constant *e*, base of the natural logarithm (means ~2.71828)
`Math.LN10`	The constant that represents the base *e* (natural) logarithm of 10
`Math.LN2`	The constant that represents the base *e* (natural) logarithm of 2
`Math.LOG10E`	The constant that represents the base 10 logarithm of *e*
`Math.LOG2E`	The constant that represents the base 2 logarithm of *e*
`Math.PI`	The π constant (~3.14159)
`Math.SQRT1_2`	The constant that represents the reciprocal of the square root of 2
`Math.SQRT2`	The constant that represents the square root of 2

Functions

All those functions are static. Math cannot be instantiated.

Math.abs()

Returns the absolute value of a number

```
Math.abs(2.5) //2.5
Math.abs(-2.5) //2.5
```

Math.acos()

Returns the arccosine of the operand

The operand must be between -1 and 1

```
Math.acos(0.8) //0.6435011087932843
```

Math.asin()

Returns the arcsine of the operand

The operand must be between -1 and 1

```
Math.asin(0.8) //0.9272952180016123
```

Math.atan()

Returns the arctangent of the operand

```
Math.atan(30) //1.5374753309166493
```

Math.atan2()

Returns the arctangent of the quotient of its arguments.

```
Math.atan2(30, 20) //0.982793723247329
```

Math.ceil()

Rounds a number up

```
Math.ceil(2.5) //3
Math.ceil(2) //2
Math.ceil(2.1) //3
Math.ceil(2.99999) //3
```

Math.cos()

Return the cosine of an angle expressed in radiants

```
Math.cos(0) //1
Math.cos(Math.PI) //-1
```

Math.exp()

Return the value of Math.E multiplied per the exponent that's passed as argument

```
Math.exp(1) //2.718281828459045
Math.exp(2) //7.38905609893065
Math.exp(5) //148.4131591025766
```

Math.floor()

Rounds a number down

```
Math.ceil(2.5) //2
Math.ceil(2) //2
Math.ceil(2.1) //2
Math.ceil(2.99999) //2
```

Math.log()

Return the base *e* (natural) logarithm of a number

```
Math.log(10) //2.302585092994046
Math.log(Math.E) //1
```

Math.max()

Return the highest number in the set of numbers passed

```
Math.max(1,2,3,4,5) //5
Math.max(1) //1
```

Math.min()

Return the smallest number in the set of numbers passed

```
Math.max(1,2,3,4,5) //1
Math.max(1) //1
```

Math.pow()

Return the first argument raised to the second argument

```
Math.pow(1, 2) //1
Math.pow(2, 1) //2
Math.pow(2, 2) //4
Math.pow(2, 4) //16
```

Math.random()

Returns a pseudorandom number between 0.0 and 1.0

```
Math.random() //0.9318168241227056
Math.random() //0.35268950194094395
```

Math.round()

Rounds a number to the nearest integer

```
Math.round(1.2) //1
Math.round(1.6) //2
```

Math.sin()

Calculates the sin of an angle expressed in radiants

```
Math.sin(0) //0
Math.sin(Math.PI) //1.2246467991473532e-16)
```

Math.sqrt()

Return the square root of the argument

```
Math.sqrt(4) //2
Math.sqrt(16) //4
Math.sqrt(5) //2.23606797749979
```

Math.tan()

Calculates the tangent of an angle expressed in radiants

```
Math.tan(0) //0
Math.tan(Math.PI) //-1.2246467991473532e-16
```

Unicode in JavaScript

Learn how to work with Unicode in JavaScript, learn what Emojis are made of, ES6 improvements and some pitfalls of handling Unicode in JS

Unicode encoding of source files

If not specified otherwise, the browser assumes the source code of any program to be written in the local charset, which varies by country and might give unexpected issues. For this reason, it's important to set the charset of any JavaScript document.

How do you specify another encoding, in particular UTF-8, the most common file encoding on the web?

If the file contains a BOM character, that has priority on determining the encoding. You can read many different opinions online, some say a BOM in UTF-8 is discouraged, and some editors won't even add it.

This is what the Unicode standard says:

> ... Use of a BOM is neither required nor recommended for UTF-8, but may be encountered in contexts where UTF-8 data is converted from other encoding forms that use a BOM or where the BOM is used as a UTF-8 signature.

This is what the W3C says:

> In HTML5 browsers are required to recognize the UTF-8 BOM and use it to detect the encoding of the page, and recent versions of major browsers handle the BOM as expected when used for UTF-8 encoded pages. -- https://www.w3.org/International/questions/qa-byte-order-mark

If the file is fetched using HTTP (or HTTPS), the **Content-Type header** can specify the encoding:

```
Content-Type: application/javascript; charset=utf-8
```

If this is not set, the fallback is to check the `charset` attribute of the `script` tag:

```
<script src="./app.js" charset="utf-8">
```

If this is not set, the document charset meta tag is used:

```
...
<head>
  <meta charset="utf-8">
</head>
...
```

The charset attribute in both cases is case insensitive (see the spec)

All this is defined in RFC 4329 "Scripting Media Types".

Public libraries should generally avoid using characters outside the ASCII set in their code, to avoid it being loaded by users with an encoding that is different than their original one, and thus create issues.

How JavaScript uses Unicode internally

While a JavaScript source file can have any kind of encoding, JavaScript will then convert it internally to UTF-16 before executing it.

JavaScript strings are all UTF-16 sequences, as the ECMAScript standard says:

> When a String contains actual textual data, each element is considered to be a single UTF-16 code unit.

Using Unicode in a string

A unicode sequence can be added inside any string using the format `\uXXXX`:

```
const s1 = '\u00E9' //é
```

A sequence can be created by combining two unicode sequences:

```
const s2 = '\u0065\u0301' //é
```

Notice that while both generate an accented e, they are two different strings, and s2 is considered to be 2 characters long:

```
s1.length //1
s2.length //2
```

And when you try to select that character in a text editor, you need to go through it 2 times, as the first time you press the arrow key to select it, it just selects half element.

You can write a string combining a unicode character with a plain char, as internally it's actually the same thing:

```
const s3 = 'e\u0301' //é
s3.length === 2 //true
s2 === s3 //true
s1 !== s3 //true
```

Normalization

Unicode normalization is the process of removing ambiguities in how a character can be represented, to aid in comparing strings, for example.

Like in the example above:

```
const s1 = '\u00E9' //é
const s3 = 'e\u0301' //é
s1 !== s3
```

ES6/ES2015 introduced the normalize() method on the String prototype, so we can simply do:

```
s1.normalize() === s3.normalize() //true
```

Emojis

Emojis are fun, and they are Unicode characters, and as such they are perfectly valid to be used in strings:

```
const s4 = '  '
```

Emojis are part of the astral planes, outside of the first Basic Multilingual Plane (BMP), and since those points outside BMP cannot be represented in 16 bits, JavaScript needs to use a combination of 2 characters to represent them

The symbol, which is `U+1F436`, is traditionally encoded as `\uD83D\uDC36` (called surrogate pair). There is a formula to calculate this, but it's a rather advanced topic.

Some emojis are also created by combining together other emojis. You can find those by looking at this list https://unicode.org/emoji/charts/full-emoji-list.html and notice the ones that have more than one item in the unicode symbol column.

 is created combining (`\uD83D\uDC69`), (`\u200D\u2764\uFE0F\u200D`) and another (`\uD83D\uDC69`) in a single string:
`\uD83D\uDC69\u200D\u2764\uFE0F\u200D\uD83D\uDC69`

There is no way to make this emoji be counted as 1 character.

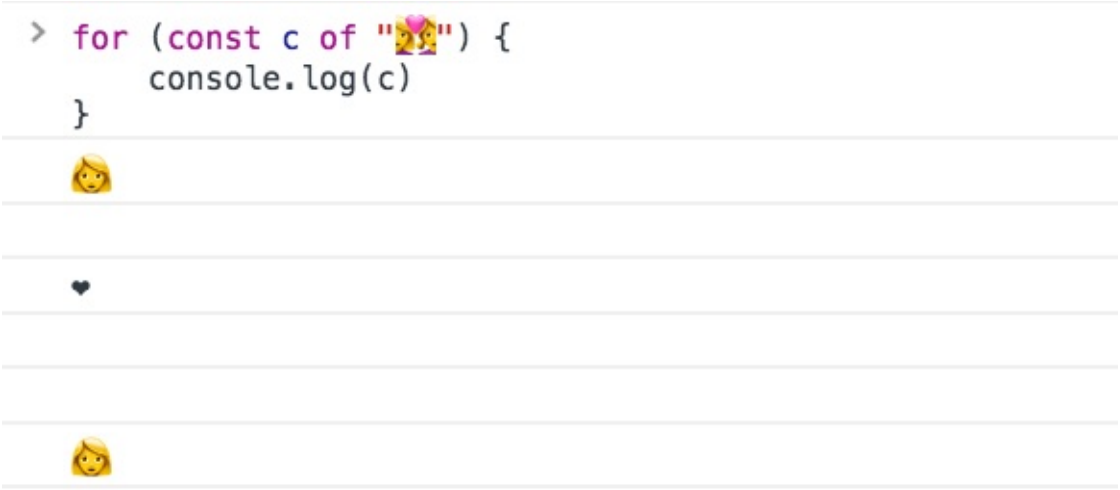
Get the proper length of a string

If you try to perform

```
'      '.length
```

You'll get 8 in return, as length counts the single Unicode code points.

Also, iterating over it is kind of funny:



And curiously, pasting this emoji in a password field it's counted 8 times, possibly making it a valid password in some systems.

How to get the "real" length of a string containing unicode characters?

One easy way in ES6+ is to use the spread operator:

```
;[...'  '].length //1
```

You can also use the Punycode library by Mathias Bynens:

```
require('punycode').ucs2.decode('  ').length //1
```

(Punycode is also great to convert Unicode to ASCII)

Note that emojis that are built by combining other emojis will still give a bad count:

```
require('punycode').ucs2.decode('      ').length //6
[...'      '].length //6
```

If the string has **combining marks** however, this still will not give the right count. Check this Glitch https://glitch.com/edit/#!/node-unicode-ignore-marks-in-length as an example.

(you can generate your own weird text with marks here: https://lingojam.com/WeirdTextGenerator)

Length is not the only thing to pay attention. Also reversing a string is error prone if not handled correctly.

ES6 Unicode code point escapes

ES6/ES2015 introduced a way to represent Unicode points in the astral planes (any Unicode code point requiring more than 4 chars), by wrapping the code in graph parentheses:

```
'\u{XXXXX}'
```

The dog symbol, which is `U+1F436`, can be represented as `\u{1F436}` instead of having to combine two unrelated Unicode code points, like we showed before: `\uD83D\uDC36`.

But `length` calculation still does not work correctly, because internally it's converted to the surrogate pair shown above.

Encoding ASCII chars

The first 128 characters can be encoded using the special escaping character `\x`, which only accepts 2 characters:

```
'\x61' // a
'\x2A' // *
```

This will only work from `\x00` to `\xFF`, which is the set of ASCII characters.

Functional Programming

Getting started with the main concepts of Functional Programming in the JavaScript Programming Language

Introduction to Functional Programming

Functional Programming (FP) is a programming paradigm with some particular techniques.

In programming languages, you'll find purely functional programming languages as well as programming languages that support functional programming techniques.

Haskell, Clojure and Scala are some of the most popular purely functional programming languages.

Popular programming languages that support functional programming techniques are JavaScript, Python, Ruby and many others.

Functional Programming is not a new concept, actually its roots go back o the 1930's when lamda calculus was born, and has influenced many programming languages.

FP has been gaining a lot of momentum lately, so it's the perfect time to learn about it.

In this course I'll introduce the main concepts of Functional Programming, by using in the code examples JavaScript.

First class functions

In a functional programming language, functions are first class citizens.

They can be assigned to variables

```
const f = (m) => console.log(m)
f('Test')
```

Since a function is assignable to a variable, they can be added to objects:

```
const obj = {
  f(m) {
    console.log(m)
  }
}
obj.f('Test')
```

as well as to arrays:

```
const a = [
  m => console.log(m)
]
a[0]('Test')
```

They can be used as an argument to other functions

```
const f = (m) => () => console.log(m)
const f2 = (f3) => f3()
f2(f('Test'))
```

They can be returned by functions

```
const createF = () => {
  return (m) => console.log(m)
```

```
}
const f = createF()
f('Test')
```

Higher Order Functions

Functions that accept functions as arguments or return functions are called **Higher Order Functions**.

Examples in the JavaScript standard library include `Array.map()`, `Array.filter()` and `Array.reduce()`, which we'll see in a bit.

Declarative programming

You may have heard the term "declarative programming".

Let's put that term in context.

The opposite of *declarative* is **imperative**.

Declarative vs Imperative

An imperative approach is when you tell the machine (in general terms), the steps it needs to take to get a job done.

A declarative approach is when you tell the machine what you need to do, and you let it figure out the details.

You start thinking declarative when you have enough level of abstraction to stop reasoning about low level constructs, and think more at a higher UI level.

One might argue that C programming is more declarative than Assembly programming, and that's true.

HTML is declarative, so if you've been using HTML since 1995, you've actually being building declarative UIs since 20+ years.

JavaScript can take both an imperative and a declarative programming approach.

For example a declarative programming approach is to avoid using loops and instead use functional programming constructs like `map`, `reduce` and `filter`, because your programs are more abstract and less focused on telling the machine each step of processing.

Immutability

In functional programming data never changes. Data is **immutable**.

A variable can never be changed. To update its value, you create a new variable.

Instead of changing an array, to add a new item you create a new array by concatenating the old array, plus the new item.

An object is never updated, but copied before changing it.

`const`

This is why the ES2015 `const` is so widely used in modern JavaScript, which embraces functional programming concepts: to **enforce** immutability on variables.

`Object.assign()`

ES2015 also gave us `Object.assign()`, which is key to creating objects:

```
const redObj = { color: 'red' }
const yellowObj = Object.assign({}, redObj, {color: 'yellow'})
```

`concat()`

To append an item to an array in JavaScript we generally use the `push()` method on an array, but that method mutates the original array, so it's not FP-ready.

We instead use the `concat()` method:

```
const a = [1, 2]
const b = [1, 2].concat(3)
// b = [1, 2, 3]
```

or we use the **spread operator**:

```
const c = [...a, 3]
// c = [1, 2, 3]
```

`filter()`

The same goes for removing an item from an array: instead of using `pop()` and `splice()`, which modify the original array, use `array.filter()`:

```
const d = a.filter((v, k) => k < 1)
// d = [1]
```

Purity

A **pure function**:

- never changes any of the parameters that get passed to it by reference (in JS, objects and arrays): they should be considered immutable. It can of course change any parameter copied by value
- the return value of a pure function is not influenced by anything else than its input parameters: passing the same parameters always result in the same output
- during its execution, a pure function does not change anything outside of it

Data Transformations

Since immutability is such an important concept and a foundation of functional programming, you might ask how can data change.

Simple: **data is changed by creating copies**.

Functions, in particular, change the data by returning new copies of data.

Core functions that do this are **map** and **reduce**.

`Array.map()`

Calling `Array.map()` on an array will create a new array with the result of a function executed on every item of the original array:

```
const a = [1, 2, 3]
const b = a.map((v, k) => v * k)
// b = [0, 2, 6]
```

`Array.reduce()`

Calling `Array.reduce()` on an array allows us to transform that array on anything else, including a scalar, a function, a boolean, an object.

You pass a function that processes the result, and a starting point:

```
const a = [1, 2, 3]
```

```
const sum = a.reduce((partial, v) => partial + v, 0)
// sum = 6
```

```
const o = a.reduce((obj, k) => { obj[k] = k; return obj }, {})
// o = {1: 1, 2: 2, 3: 3}
```

Recursion

Recursion is a key topic in functional programming. when **a function calls itself**, it's called a *recursive function*.

The classic example of recursion is the Fibonacci sequence (N = (N-1 + N-2)) calculation, here in its 2^N totally inefficient (but nice to read) solution:

```
var f = (n) => n <= 1 ? 1 : f(n-1) + f(n-2)
```

Composition

Composition is another key topic of Functional Programming, a good reason to put it into the "key topics" list.

Composition is how we generate a higher order function, by combining simpler functions.

Composing in plain JS

A very common way to compose functions in plain JavaScript is to chain them:

```
obj.doSomething()
   .doSomethingElse()
```

or, also very widely used, by passing a function execution into a function:

```
obj.doSomething(doThis())
```

Composing with the help of `lodash`

More generally, composing is the act of putting together a list of many functions to perform a more complicated operation.

`lodash/fp` comes with an implementation of `compose`: we execute a list of functions, starting with an argument, **each function inherits the argument from the preceding function return value**. Notice how we don't need to store intermediate values anywhere.

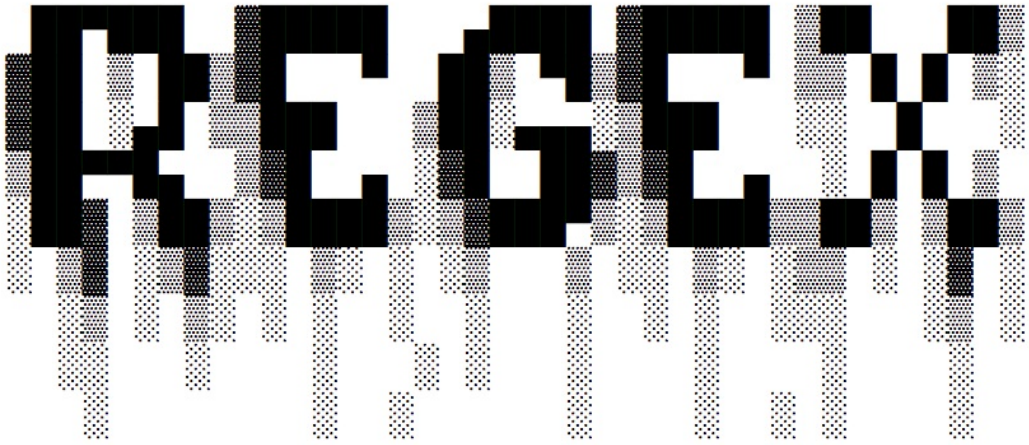
```
import { compose } from 'lodash/fp'

const slugify = compose(
  encodeURIComponent,
  join('-'),
  map(toLowerCase),
  split(' ')
)

slufigy('Hello World') // hello-world
```

Regular Expressions

Learn everything about JavaScript Regular Expressions with this brief guide that summarizes the most important concepts and shows them off with examples



Introduction to Regular Expressions

A regular expression (also called **regex**) is a way to work with strings, in a very performant way.

By formulating a regular expression with a special syntax, you can

- **search text** a string
- **replace substrings** in a string
- **extract information** from a string

Almost every programming language implements regular expressions. There are small differences between each implementation, but the general concepts apply almost everywhere.

Regular Expressions date back to the 1950s, when it was formalized as a conceptual search pattern for string processing algorithms.

Implemented in UNIX tools like grep, sed, and in popular text editors, regexes grew in popularity and were introduced in the Perl programming language, and later in many others.

JavaScript, among with Perl, is one of the programming languages that have regular expressions support directly built in the language.

Hard but useful

Regular expressions can appear like absolute nonsense to the beginner, and many times also to the professional developer, if one does not invest the time necessary to understand them.

Cryptic regular expressions are **hard to write**, **hard to read**, and **hard to maintain/modify**.

But sometimes a regular expression is **the only sane way** to perform some string manipulation, so it's a very valuable tool in your pocket.

This tutorial aims to introduce you to JavaScript Regular Expressions in a simple way, and give you all the information to read and create regular expressions.

The rule of thumb is that **simple regular expressions are simple** to read and write, while **complex regular expressions can quickly turn into a mess** if you don't deeply grasp the basics.

How does a Regular Expression look like

In JavaScript, a regular expression is an **object**, which can be defined in two ways.

The first is by instantiating a **new RegExp object** using the constructor:

```
const re1 = new RegExp('hey')
```

The second is using the **regular expression literal** form:

```
const re1 = /hey/
```

You know that JavaScript has *object literals* and *array literals*? It also has *regex literals*.

In the example above, `hey` is called the **pattern**. In the literal form it's delimited by forward slashes, while with the object constructor, it's not.

This is the first important difference between the two forms, but we'll see others later.

How does it work?

The regular expression we defined as `re1` above is a very simple one. It searches the string `hey`, without any limitation: the string can contain lots of text, and `hey` in the middle, and the regex is satisfied. It could also contains just `hey`, and it will be satisfied as well.

That's pretty simple.

You can test the regex using `RegExp.test(String)`, which returns a boolean:

```
re1.test('hey')                    //
re1.test('blablabla hey blablabla') //


re1.test('he')        //
re1.test('blablabla') //
```

In the above example we just checked if `"hey"` satisfies the regular expression pattern stored in `re1`.

This is the simplest it can be, but you already know lots of concepts about regexes.

Anchoring

```
/hey/
```

matches `hey` wherever it was put inside the string.

If you want to match strings that **start** with `hey`, use the `^` operator:

```
/^hey/.test('hey')     //
/^hey/.test('bla hey') //
```

If you want to match strings that **end** with `hey`, use the `$` operator:

```
/hey$/.test('hey')     //
/hey$/.test('bla hey') //
/hey$/.test('hey you') //
```

Combine those, and match strings that exactly match `hey`, and just that string:

```
/^hey$/.test('hey') //
```

To match a string that starts with a substring and ends with another, you can use `.*`, which matches any character repeated 0 or more times:

```
/^hey.*joe$/.test('hey joe')             //
/^hey.*joe$/.test('heyjoe')              //
/^hey.*joe$/.test('hey how are you joe') //
/^hey.*joe$/.test('hey joe!')            //
```

Match items in ranges

Instead of matching a particular string, you can choose to match any character in a range, like:

```
/[a-z]/ //a, b, c, ... , x, y, z
/[A-Z]/ //A, B, C, ... , X, Y, Z
/[a-c]/ //a, b, c
/[0-9]/ //0, 1, 2, 3, ... , 8, 9
```

These regexes match strings that contain at least one of the characters in those ranges:

```
/[a-z]/.test('a')  //
/[a-z]/.test('1')  //
/[a-z]/.test('A')  //

/[a-c]/.test('d')  //
/[a-c]/.test('dc') //
```

Ranges can be combined:

```
/[A-Za-z0-9]/
```

```
/[A-Za-z0-9]/.test('a') //
/[A-Za-z0-9]/.test('1') //
/[A-Za-z0-9]/.test('A') //
```

Matching a range item multiple times

You can check if a string contains one an only one character in a range, by using the `-` char:

```
/^[A-Za-z0-9]$/

/^[A-Za-z0-9]$/.test('A')  //
/^[A-Za-z0-9]$/.test('Ab') //
```

Negating a pattern

The `^` character at the beginning of a pattern anchors it to the beginning of a string.

Used inside a range, it **negates** it, so:

```
/[^A-Za-z0-9]/.test('a') //
/[^A-Za-z0-9]/.test('1') //
/[^A-Za-z0-9]/.test('A') //
/[^A-Za-z0-9]/.test('@') //
```

Meta characters

- `\d` matches any digit, equivalent to `[0-9]`
- `\D` matches any character that's not a digit, equivalent to `[^0-9]`
- `\w` matches any alphanumeric character, equivalent to `[A-Za-z0-9]`
- `\W` matches any non-alphanumeric character, equivalent to `[^A-Za-z0-9]`
- `\s` matches any whitespace character: spaces, tabs, newlines and Unicode spaces
- `\S` matches any character that's not a whitespace
- `\0` matches null
- `\n` matches a newline character
- `\t` matches a tab character
- `\uxxxx` matches a unicode character with code XXXX (requires the `u` flag)
- `.` matches any character that is not a newline char (e.g. `\n`) (unless you use the `s` flag, explained later on)
- `[^]` matches any character, including newline characters. It's useful on multiline strings

Regular expressions choices

If you want to search one string **or** another, use the `|` operator.

```
/hey|ho/.test('hey') //
/hey|ho/.test('ho')  //
```

Quantifiers

Say you have this regex, that checks if a string has one digit in it, and nothing else:

```
/^\d$/
```

You can use **the `?` quantifier** to make it optional, thus requiring zero or one:

```
/^\d?$/
```

but what if you want to match multiple digits?

You can do it in 4 ways, using `+`, `*`, `{n}` and `{n,m}`.

`+`

Match one or more (>=1) items

```
/^\d+$/

/^\d+$/.test('12')     //
/^\d+$/.test('14')     //
/^\d+$/.test('144343') //
/^\d+$/.test('')       //
/^\d+$/.test('1a')     //
```

`*`

Match 0 or more (>= 0) items

```
/^\d+$/

/^\d*$/.test('12')     //
/^\d*$/.test('14')     //
/^\d*$/.test('144343') //
/^\d*$/.test('')       //
/^\d*$/.test('1a')     //
```

`{n}`

Match exactly `n` items

```
/^\d{3}$/

/^\d{3}$/.test('123')  //
/^\d{3}$/.test('12')   //
/^\d{3}$/.test('1234') //

/^[A-Za-z0-9]{3}$/.test('Abc') //
```

`{n,m}`

Match between `n` and `m` times:

```
/^\d{3,5}$/

/^\d{3,5}$/.test('123')    //
/^\d{3,5}$/.test('1234')   //
/^\d{3,5}$/.test('12345')  //
/^\d{3,5}$/.test('123456') //
```

`m` can be omitted to have an open ending to have at least `n` items:

```
/^\d{3,}$/

/^\d{3,}$/.test('12')        //
/^\d{3,}$/.test('123')       //
/^\d{3,}$/.test('12345')     //
/^\d{3,}$/.test('123456789') //
```

Optional items

Following an item with `?` makes it optional:

```
/^\d{3}\w?$/

/^\d{3}\w?$/.test('123')   //
/^\d{3}\w?$/.test('123a')  //
/^\d{3}\w?$/.test('123ab') //
```

Groups

Using parentheses, you can create groups of characters: `(...)`

This example matches exactly 3 digits followed by one or more alphanumeric characters:

```
/^(\d{3})(\w+)$/

/^(\d{3})(\w+)$/.test('123')          //
/^(\d{3})(\w+)$/.test('123s')         //
/^(\d{3})(\w+)$/.test('123something') //
/^(\d{3})(\w+)$/.test('1234')         //
```

Repetition characters put after a group closing parentheses refer to the whole group:

```
/^(\d{2})+$/

/^(\d{2})+$/.test('12')   //
/^(\d{2})+$/.test('123')  //
```

```
/^(\d{2})+$/.test('1234') //
```

Capturing Groups

So far, we've seen how to test strings and check if they contain a certain pattern.

A very cool feature of regular expressions is the ability to **capture parts of a string**, and put them into an array.

You can do so using Groups, and in particular **Capturing Groups**.

By default, a Group is a Capturing Group. Now, instead of using `RegExp.test(String)`, which just returns a boolean if the pattern is satisfied, we use one of

- `String.match(RegExp)`
- `RegExp.exec(String)`

They are exactly the same, and return an Array with the whole matched string in the first item, then each matched group content.

If there is no match, it returns `null`:

```
'123s'.match(/^(\d{3})(\w+)$/)
//Array [ "123s", "123", "s" ]

/^(\d{3})(\w+)$/.exec('123s')
//Array [ "123s", "123", "s" ]

'hey'.match(/(hey|ho)/)
//Array [ "hey", "hey" ]

/(hey|ho)/.exec('hey')
//Array [ "hey", "hey" ]

/(hey|ho)/.exec('ha!')
//null
```

When a group is matched multiple times, only the last match is put in the result array:

```
'123456789'.match(/(\d)+/)
//Array [ "123456789", "9" ]
```

Optional groups

A capturing group can be made optional by using `(...)?`. If it's not found, the resulting array slot will contain `undefined`:

```
/^(\d{3})(\s)?(\w+)$/.exec('123 s') //Array [ "123 s", "123", " ", "s" ]
/^(\d{3})(\s)?(\w+)$/.exec('123s') //Array [ "123s", "123", undefined, "s" ]
```

Reference matched groups

Every group that's matched is assigned a number. `$1` refers to the first, `$2` to the second, and so on. This will be useful when we'll later talk about replacing parts of a string.

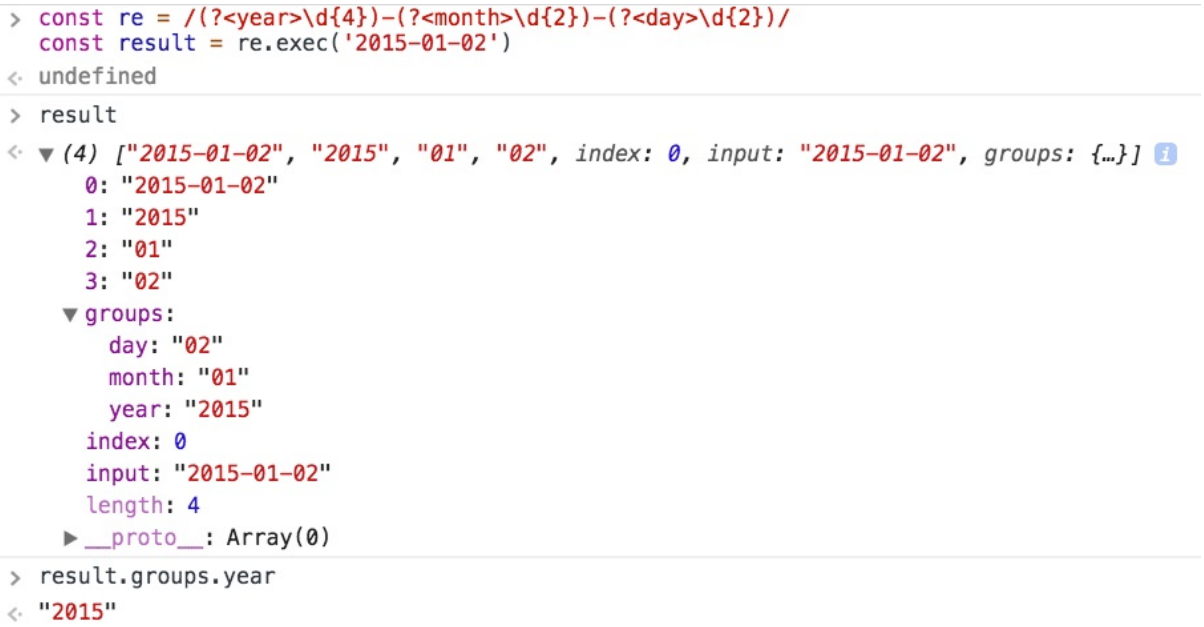
Named Capturing Groups

This is a new, ES2018 feature.

A group can be assigned to a name, rather than just being assigned a slot in the result array:

```
const re = /(?<year>\d{4})-(?<month>\d{2})-(?<day>\d{2})/
const result = re.exec('2015-01-02')

// result.groups.year === '2015';
// result.groups.month === '01';
// result.groups.day === '02';
```



Using match and exec without groups

There is a difference with using `match` and `exec` without groups: the first item in the array is not the whole matched string, but the match directly:

```
/hey|ho/.exec('hey')   // [ "hey" ]
```

```
/(hey).(ho)/.exec('hey ho') // [ "hey ho", "hey", "ho" ]
```

Noncapturing Groups

Since by default groups are Capturing Groups, you need a way to ignore some groups in the resulting array. This is possible using **Noncapturing Groups**, which start with an `(?:...)`

```
'123s'.match(/^(\d{3})(?:\s)(\w+)$/)
//null
'123 s'.match(/^(\d{3})(?:\s)(\w+)$/)
//Array [ "123 s", "123", "s" ]
```

Flags

You can use the following flags on any regular expression:

- `g` : matches the pattern multiple times
- `i` : makes the regex case insensitive
- `m` : enables multiline mode. In this mode, `^` and `$` match the start and end of the whole string. Without this, with multiline strings they match the beginning and end of each line.
- `u` : enables support for unicode (introduced in ES6/ES2015)
- `s` : (new in ES2018) short for *single line*, it causes the `.` to match new line characters as well

Flags can be combined, and they are added at the end of the string in regex literals:

```
/hey/ig.test('HEy') //
```

or as the second parameter with RegExp object constructors:

```
new RegExp('hey', 'ig').test('HEy') //
```

Inspecting a regex

Given a regex, you can inspect its properties:

- `source` the pattern string
- `multiline` true with the `m` flag

- `global` true with the `g` flag
- `ignoreCase` true with the `i` flag
- `lastIndex`

```
/^(\w{3})$/i.source     //"^(\\d{3})(\\w+)$"
/^(\w{3})$/i.multiline  //false
/^(\w{3})$/i.lastIndex  //0
/^(\w{3})$/i.ignoreCase //true
/^(\w{3})$/i.global     //false
```

Escaping

These characters are special:

- `\`
- `/`
- `[ ]`
- `( )`
- `{ }`
- `?`
- `+`
- `*`
- `|`
- `.`
- `^`
- `$`

They are special because they are control characters that have a meaning in the regular expression pattern, so if you want to use them inside the pattern as matching characters, you need to escape them, by prepending a backslash:

```
/^\\$/
/^\^$/ // /^\^$/.test('^')
/^\$$/ // /^\$$/.test('$')
```

String boundaries

`\b` and `\B` let you inspect whether a string is at the beginning or at the end of a word:

- **`\b`** matches a set of characters at the beginning or end of a word
- **`\B`** matches a set of characters not at the beginning or end of a word

Example:

```
'I saw a bear'.match(/\bbear/)    //Array ["bear"]
'I saw a beard'.match(/\bbear/)   //Array ["bear"]
'I saw a beard'.match(/\bbear\b/) //null
'cool_bear'.match(/\bbear\b/)     //null
```

Replacing using Regular Expressions

We already saw how to check if a string contains a pattern.

We also saw how to extract parts of a string to an array, matching a pattern.

Let's see how to **replace parts of a string** based on a pattern.

The `String` object in JavaScript has a replace() method, which can be used without regular expressions to perform a *single replacement* on a string:

```
"Hello world!".replace('world', 'dog') //Hello dog!
"My dog is a good dog!".replace('dog', 'cat') //My cat is a good dog!
```

This method also accepts a regular expression as argument:

```
"Hello world!".replace(/world/, 'dog') //Hello dog!
```

Using the `g` flag is **the only way** to replace multiple occurrences in a string in vanilla JavaScript:

```
"My dog is a good dog!".replace(/dog/g, 'cat') //My cat is a good cat!
```

Groups let us do more fancy things, like moving around parts of a string:

```
"Hello, world!".replace(/(\w+), (\w+)!/, '$2: $1!!!')
// "world: Hello!!!"
```

Instead of using a string you can use a function, to do even fancier things. It will receive a number of arguments like the one returned by `String.match(RegExp)` or `RegExp.exec(String)`, with a number of arguments that depends on the number of groups:

```
"Hello, world!".replace(/(\w+), (\w+)!/, (matchedString, first, second) => {
  console.log(first);
  console.log(second);
```

```
  return `${second.toUpperCase()}: ${first}!!!`
})
//"WORLD: Hello!!!"
```

Greediness

Regular expressions are said to be **greedy** by default.

What does it mean?

Take this regex

```
/\$(.+)\s?/
```

It is supposed to extract a dollar amount from a string

```
/\$(.+)\s?/.exec('This costs $100')[1]
//100
```

but if we have more words after the number, it freaks off

```
/\$(.+)\s?/.exec('This costs $100 and it is less than $200')[1]
//100 and it is less than $200
```

Why? Because the regex after the $ sign matches any character with `.+`, and it won't stop until it reaches the end of the string. Then, it finishes off because `\s?` makes the ending space optional.

To fix this, we need to tell the regex to be lazy, and perform the least amount of matching possible. We can do so using the `?` symbol after the quantifier:

```
/\$(.+?)\s/.exec('This costs $100 and it is less than $200')[1]
//100
```

> I removed the `?` after `\s` otherwise it matched only the first number, since the space was optional

So, `?` means different things based on its position, because it can be both a quantifier and a lazy mode indicator.

Lookaheads: match a string depending on what follows it

Use `?=` to match a string that's followed by a specific substring:

```
/Roger(?=Waters)/

/Roger(?= Waters)/.test('Roger is my dog') //false
/Roger(?= Waters)/.test('Roger is my dog and Roger Waters is a famous musician') //true
```

`?!` performs the inverse operation, matching if a string is **not** followed by a specific substring:

```
/Roger(?!Waters)/

/Roger(?! Waters)/.test('Roger is my dog') //true
/Roger(?! Waters)/.test('Roger Waters is a famous musician') //false
```

Lookbehinds: match a string depending on what precedes it

This is an ES2018 feature.

Lookaheads use the `?=` symbol. Lookbehinds use `?<=`.

```
/(?<=Roger) Waters/

/(?<=Roger) Waters/.test('Pink Waters is my dog') //false
/(?<=Roger) Waters/.test('Roger is my dog and Roger Waters is a famous musician') //true
```

A lookbehind is negated using `?<!`:

```
/(?<!Roger) Waters/

/(?<!Roger) Waters/.test('Pink Waters is my dog') //true
/(?<!Roger) Waters/.test('Roger is my dog and Roger Waters is a famous musician') //false
```

Regular Expressions and Unicode

The `u` flag is mandatory when working with Unicode strings, in particular when you might need to handle characters in astral planes, the ones that are not included in the first 1600 Unicode characters.

Like Emojis, for example, but not just those.

If you don't add that flag, this simple regex that should match one character will not work, because for JavaScript that emoji is represented internally by 2 characters (see Unicode in JavaScript):

```
/^.$/.test('a') //
/^.$/.test('  ') //
/^.$/u.test('  ') //
```

So, always use the `u` flag.

Unicode, just like normal characters, handle ranges:

```
/[a-z]/.test('a')  //
/[1-9]/.test('1')  //

/[  -  ]/u.test('  ')  //
/[  -  ]/u.test('  ')  //
```

JavaScript checks the internal code representation, so < < because `\u1F436` < `\u1F43A` < `\u1F98A`. Check the full Emoji list to get those codes, and to find out the order (tip: the macOS Emoji picker has some emojis in a mixed order, don't count on it)

Unicode property escapes

As we saw above, in a regular expression pattern you can use `\d` to match any digit, `\s` to match any character that's not a white space, `\w` to match any alphanumeric character, and so on.

Unicode property escapes is an ES2018 feature that introduces a very cool feature, extending this concept to all Unicode characters introducing `\p{}` and is negation `\P{}`.

Any unicode character has a set of properties. For example `Script` determines the language family, `ASCII` is a boolean that's true for ASCII characters, and so on. You can put this property in the graph parentheses, and the regex will check for that to be true:

```
/^\p{ASCII}+$/u.test('abc')   //
/^\p{ASCII}+$/u.test('ABC@')  //
/^\p{ASCII}+$/u.test('ABC  ') //
```

`ASCII_Hex_Digit` is another boolean property, that checks if the string only contains valid hexadecimal digits:

```
/^\p{ASCII_Hex_Digit}+$/u.test('0123456789ABCDEF') //
/^\p{ASCII_Hex_Digit}+$/u.test('h')                //
```

There are many other boolean properties, which you just check by adding their name in the graph parentheses, including `Uppercase`, `Lowercase`, `White_Space`, `Alphabetic`, `Emoji` and more:

```
/^\p{Lowercase}$/u.test('h') //
/^\p{Uppercase}$/u.test('H') //

/^\p{Emoji}+$/u.test('H')   //
/^\p{Emoji}+$/u.test('     ') //
```

In addition to those binary properties, you can check any of the unicode character properties to match a specific value. In this example, I check if the string is written in the greek or latin alphabet:

```
/^\p{Script=Greek}+$/u.test('ελληνικά') //
/^\p{Script=Latin}+$/u.test('hey') //
```

Read more about all the properties you can use directly on the proposal.

Examples

Extract a number from a string

Supposing a string has only one number you need to extract, `/\d+/` should do it:

```
'Test 123123329'.match(/\d+/)
// Array [ "123123329" ]
```

Match an email address

A simplistic approach is to check non-space characters before and after the `@` sign, using `\S`:

```
/(\S+)@(\S+)\.(\S+)/

/(\S+)@(\S+)\.(\S+)/.exec('copesc@gmail.com')
//["copesc@gmail.com", "copesc", "gmail", "com"]
```

This is a simplistic example however, as many invalid emails are still satisfied by this regex.

Capture text between double quotes

Suppose you have a string that contains something in double quotes, and you want to extract that content.

The best way to do so is by using a **capturing group**, because we know the match starts and ends with `"`, and we can easily target it, but we also want to remove those quotes from our result.

We'll find what we need in `result[1]`:

```
const hello = 'Hello "nice flower"'
const result = /"([^']*)"/.exec(hello)
//Array [ "\"nice flower\"", "nice flower" ]
```

Get the content inside an HTML tag

For example get the content inside a span tag, allowing any number of arguments inside the tag:

```
/<span\b[^>]*>(.*?)<\/span>/

/<span\b[^>]*>(.*?)<\/span>/.exec('test')
// null
/<span\b[^>]*>(.*?)<\/span>/.exec('<span>test</span>')
// ["<span>test</span>", "test"]
/<span\b[^>]*>(.*?)<\/span>/.exec('<span class="x">test</span>')
// ["<span class="x">test</span>", "test"]
```

Glossary

A guide to a few terms used in frontend development that might be alien to you

Asynchronous

Code is asynchronous when you initiate something, forget about it, and when the result is ready you get it back without having to wait for it. The typical example is an AJAX call, which might take even seconds and in the meantime you complete other stuff, and when the response is ready, the callback function gets called. Promises and async/await are the modern way to handle async.

Block

In JavaScript a block is delimited curly braces (`{}`). An `if` statement contains a block, a `for` loop contains a block.

Block Scoping

With Function Scoping, any variable defined in a block is visible and accessible from inside the whole block, but not outside of it.

Callback

A callback is a function that's invoked when something happens. A click event associated to an element has a callback function that's invoked when the user clicks the element. A fetch request has a callback that's called when the resource is downloaded.

Declarative

A declarative approach is when you tell the machine what you need to do, and you let it figure out the details. React is considered declarative, as you reason about abstractions rather than editing the DOM directly. Every high level programming language is more declarative than a low level programming language like Assembler. JavaScript is more declarative than C. HTML is declarative.

Fallback

A fallback is used to provide a good experience when a user hasn't access to a particular functionality. For example a user that browses with JavaScript disabled should be able to have a fallback to a plain HTML version of the page. Or for a browser that has not implemented an API, you should have a fallback to avoid completely breaking the experience of the user.

Function Scoping

With Function Scoping, any variable defined in a function is visible and accessible from inside the whole function.

Immutability

A variable is immutable when its value cannot change after it's created. A mutable variable can be changed. The same applies to objects and arrays.

Lexical Scoping

Lexical Scoping is a particular kind of scoping where variables of a parent function are made available to inner functions as well. The scope of an inner function also includes the scope of a parent function.

Polyfill

A polyfill is a way to provide new functionality available in modern JavaScript or a modern browser API to older browsers. A polyfill is a particular kind of shim.

Pure function

A function that has no side effects (does not modify external resources), and its output is only determined by the arguments. You could call this function 1M times, and given the same set of arguments, the output will always be the same.

Reassignment

JavaScript with `var` and `let` declaration allows you to reassign a variable indefinitely. With `const` declarations you effectively declare an immutable value for strings, integers, booleans, and an object that cannot be reassigned (but you can still modify it through its methods).

Scope

Scope is the set of variables that's visible to a part of the program.

Scoping

Scoping is the set of rules that's defined in a programming language to determine the value of a variable.

Shim

A shim is a little wrapper around a functionality, or API. It's generally used to abstract something, pre-fill parameters or add a polyfill for browsers that do not support some functionality. You can consider it like a compatibility layer.

Side effect

A side effect is when a function interacts with some other function or object outside it. Interaction with the network or the file system, or with the UI, are all side effects.

State

State usually comes into play when talking about Components. A component can be stateful if it manages its own data, or stateless if it doesn't.

Stateful

A stateful component, function or class manages its own state (data). It could store an array, a counter or anything else.

Stateless

A stateless component, function or class is also called *dumb* because it's incapable of having its own data to make decisions, so its output or presentation is entirely based on its arguments. This implies that pure functions are stateless.

Strict mode

Strict mode is an ECMAScript 5.1 new feature, which causes the JavaScript runtime to catch more errors, but it helps you improve the JavaScript code by denying undeclared variables and other things that might cause overlooked issues like duplicated object properties and other subtle things. Hint: use it. The alternative is "sloppy mode" which is not a good thing even looking at the name we gave it.

Tree Shaking

Tree shaking means removing "dead code" from the bundle you ship to your users. If you add some code that you never use in your import statements, that's not going to be sent to the users of your app, to reduce file size and loading time.