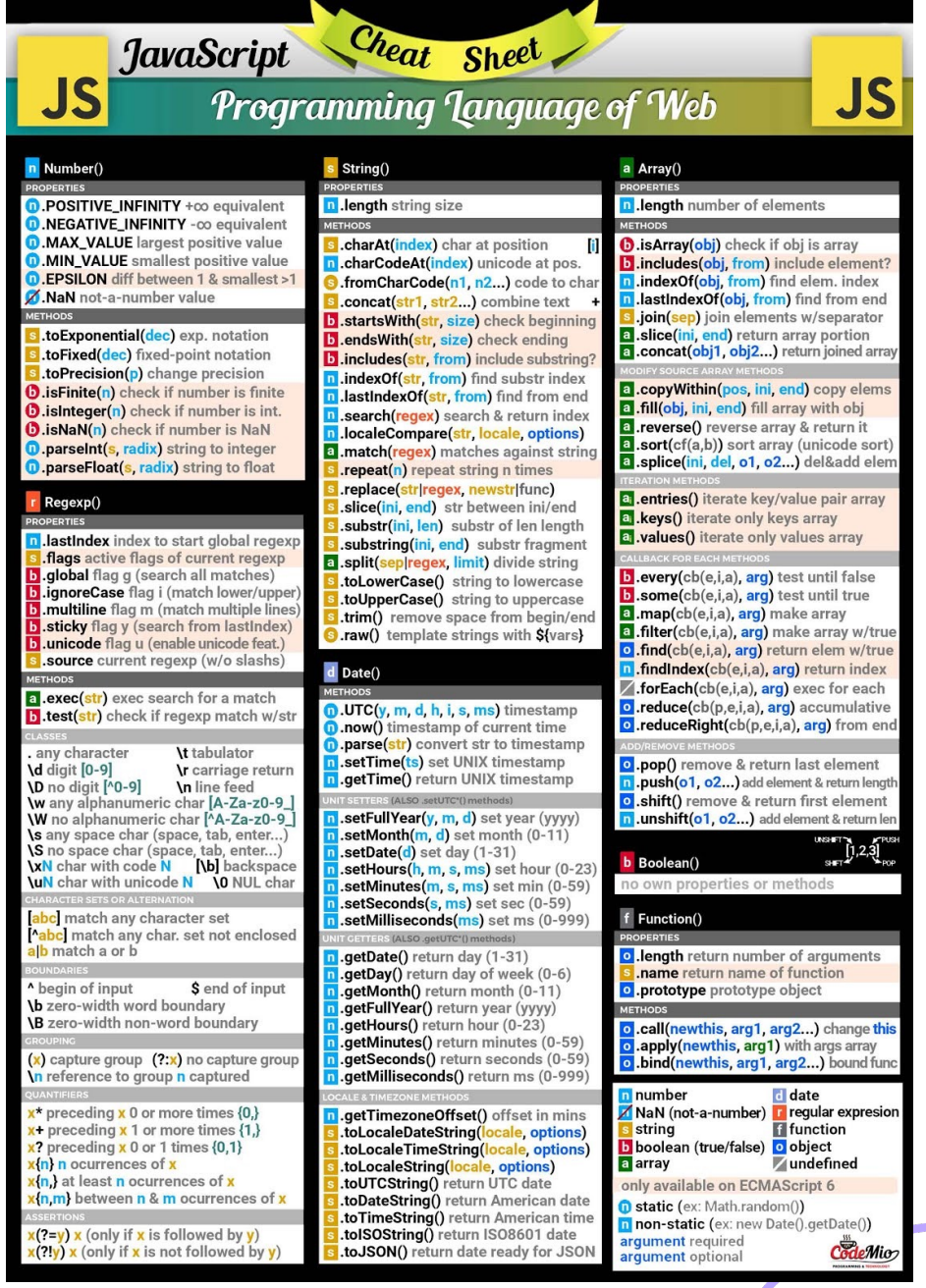
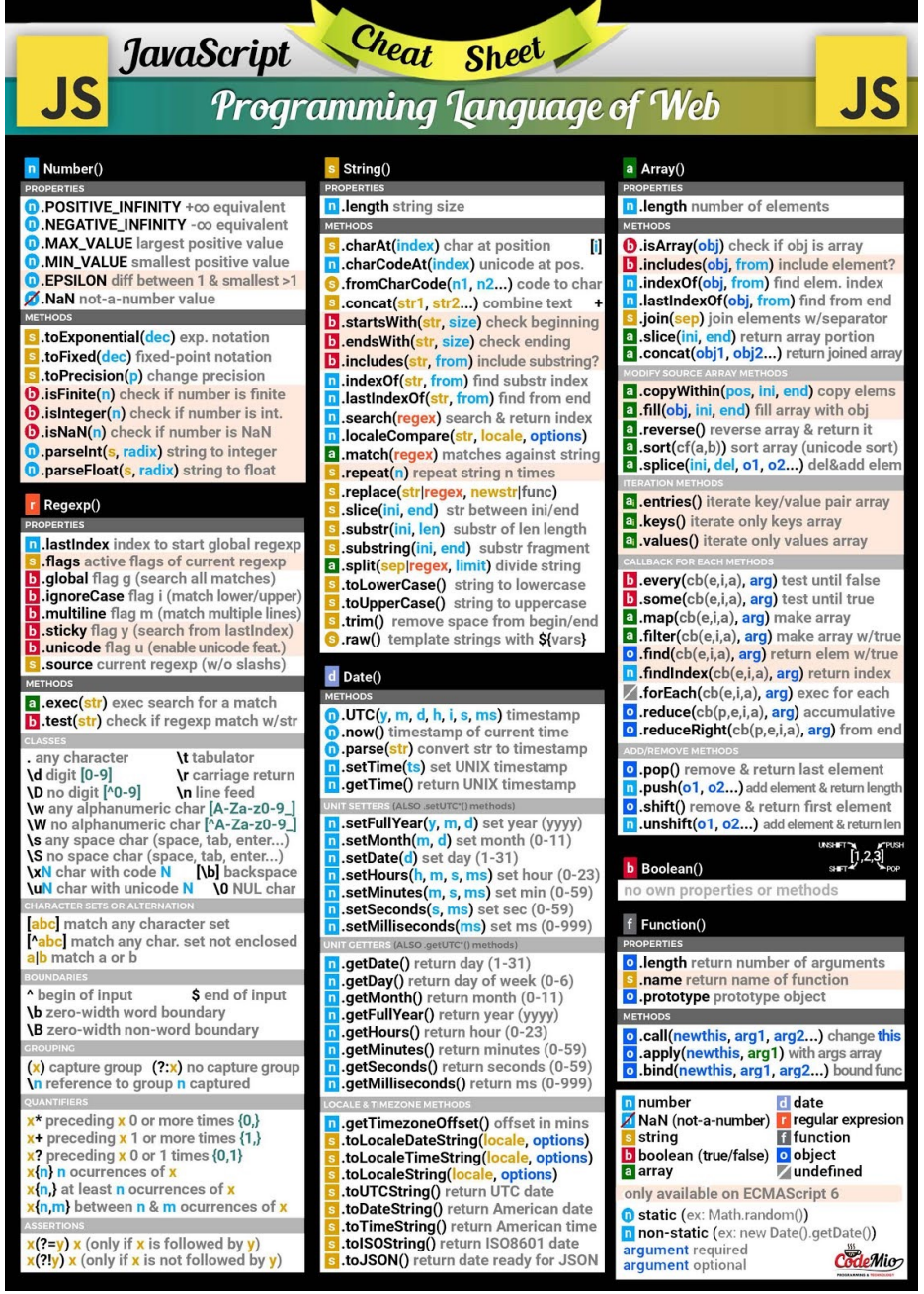
Intro
<AppWeb/>
2022

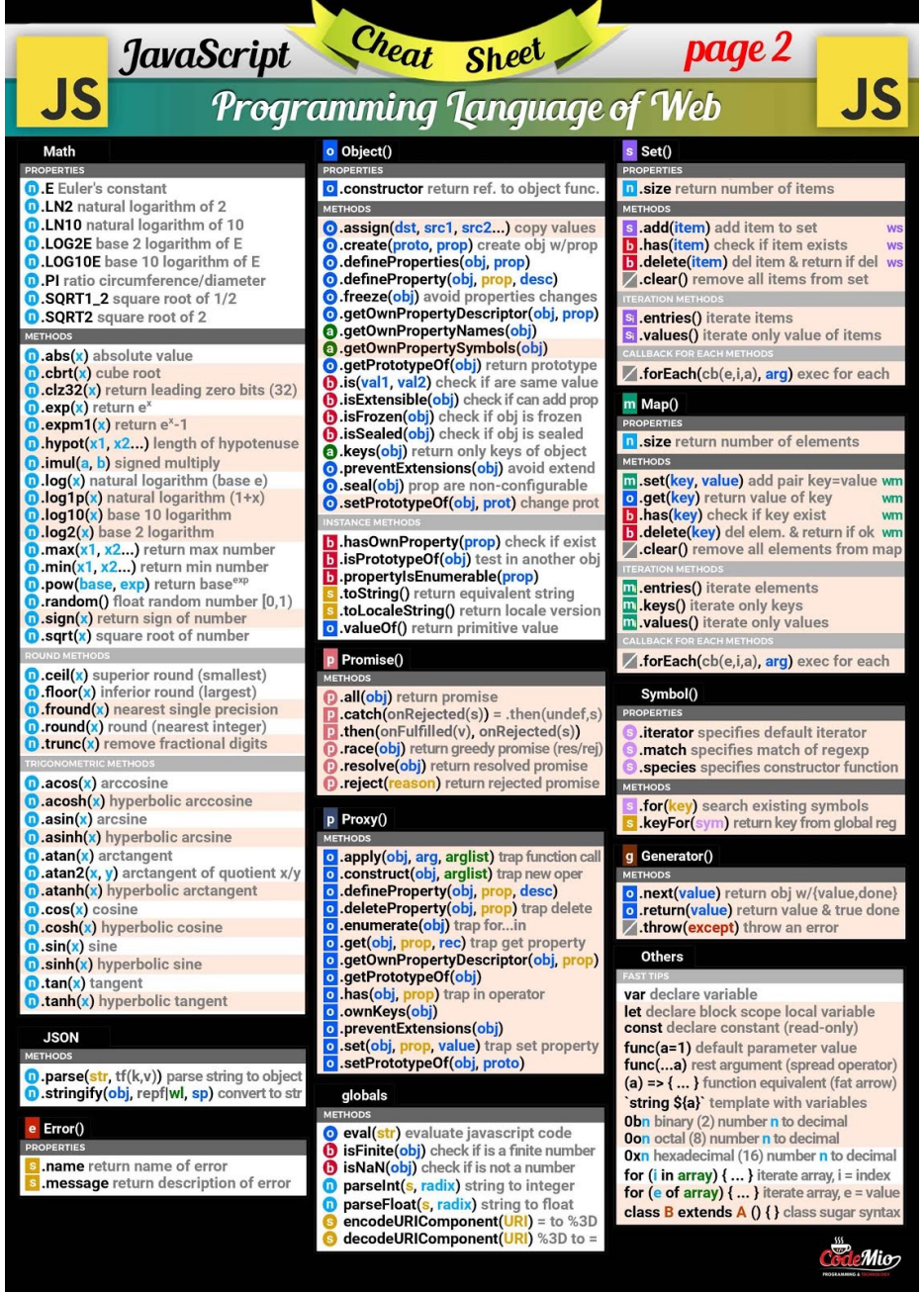
JavaScript (basics)

"The" language of the Web

Alberto Monge Roffarello







https://www.codemio.com/2016/09/html5-css3-javascript-cheat-sheets.html

Goal

- Introducing JavaScript
- Understand the specific semantics and some programming patterns
- Objects, Functions, and Dates
- Updated to ES6 (2015) language features
- Supported by client-side (browsers) run-time environment

Outline

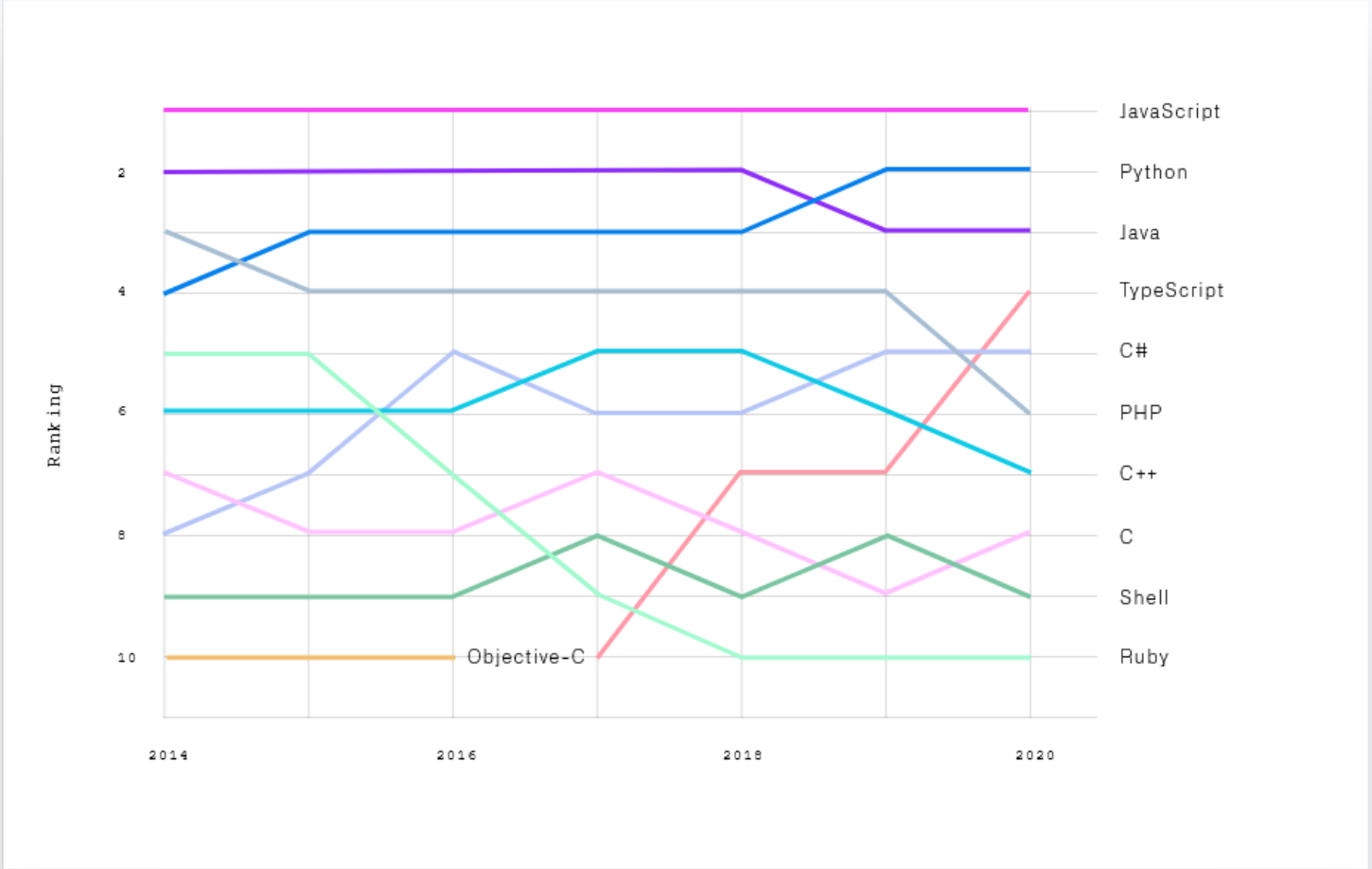
- What is JavaScript?
- History and versions
- Language structure
- Types, variables
- Expressions
- Control structures
- Arrays
- Strings
- Functions

JavaScript – The language of the Web

WHAT IS JAVASCRIPT?

// The languages that dominated

Top languages over the years



source: https://octoverse.github.com/#top-languages

JavaScript

- JavaScript (JS) is a programming language
- It is currently the only programming language that a browser can execute natively…
- … and it also run on a computer, like other programming languages (thanks to Node.js)
- It has **nothing** to do with Java
  - named that way for *marketing reasons*, only
- The first version was written in 10 days (!)
  - several fundamental language decisions were made because of company politics and not technical reasons!

JavaScript – The language of the Web

HISTORY AND VERSIONS

JAVASCRIPT VERSIONS


Brendan Eich

- **JAVASCRIPT (December 4th 1995)** Netscape and Sun press release
- **ECMAScript Standard Editions:** https://www.ecma-international.org/ecma-262/
  - **ES1 (June 1997)** Object-based, Scripting, Relaxed syntax, Prototypes
  - **ES2 (June 1998)** Editorial changes for ISO 16262
  - **ES3 (December 1999)** Regexps, Try/Catch, Do-While, String methods

10 yrs

  - **ES5 (December 2009)** Strict mode, JSON, .bind, Object mts, Array mts
  - **ES5.1 (June 2011)** Editorial changes for ISO 16262:2011

Main target

  - **ES6 (June 2015)** Classes, Modules, Arrow Fs, Generators, Const/Let, Destructuring, Template Literals, Promise, Proxy, Symbol, Reflect — Also: ES2015
  - **ES7 (June 2016)** Exponentiation operator (**) and Array Includes — Also: ES2016

ES9, ES10, …

  - **ES8 (June 2017)** Async Fs, Shared Memory & Atomics — Also: ES2017

https://www.slideshare.net/RafaelCasusoRomate/javascript-editions-es7-es8-and-es9-vs-v8

JavaScript versions

- ECMAScript (also called ES) is the official name of JavaScript (JS) standard
- ES6, ES2015, ES2016 etc. are implementations of the standard
- All browsers used to run ECMAScript 3
- ES5, and ES2015 (=ES6) were huge versions of JavaScript
- Then, yearly release cycles started
  - By the committee behind JS: TC39, backed by Mozilla, Google, Facebook, Apple, Microsoft, Intel, PayPal, SalesForce, etc.
- **ES2015 (=ES6) is covered in this course**

Official ECMA standard (formal and unreadable)

https://www.ecma-international.org/ecma-262/

JavaScript Engines

- V8 (Chrome V8) by Google
  - used in Chrome/Chromium, Node.js and Microsoft Edge
- SpiderMonkey by Mozilla Foundation
  - Used in Firefox/Gecko
- ChakraCore by Microsoft
  - it was used in Edge
- JavaScriptCore by Apple
  - used in Safari

Standard vs. Implementation (in browsers)

Browser compatibility

Update compatibility data on GitHub

	Chrome	Edge	Firefox	Internet Explorer	Opera	Safari	Android webview	Chrome for Android	Firefox for Android	Opera for Android	Safari on iOS	Samsung Internet
FetchEvent	40	Yes	44 ★	No	27	No	40	40	44	27	No	4.0
FetchEvent() constructor	40	Yes	44 ★	No	27	No	40	40	44	27	No	4.0
client	42	?	44	No	27	No	42	44	No	?	No	4.0
clientId	49	?	45 ★	No	36	No	49	49	45	36	No	5.0
isReload	45	17	44 ★	No	32	No	45	45	44	32	No	5.0
navigationPreload	59	?	?	No	46	No	59	59	?	43	No	7.0
preloadResponse	59	18	?	No	46	No	59	59	?	43	No	7.0
replacesClientId	No	18	65	No	No	No	No	No	65	No	No	No
request	Yes	?	44	No	Yes	No	Yes	Yes	?	Yes	No	Yes
respondWith	42 ★	?	59 ★	No	29	No	42 ★	42 ★	?	29	No	4.0
resultingClientId	72	18	65	No	60	No	72	72	65	50	No	No
targetClientId	?	?	?	No	?	No	?	?	?	?	No	?

What are we missing?

Full support

No support

Compatibility unknown

Experimental. Expect behavior to change in the future.

Non-standard. Expect poor cross-browser support.

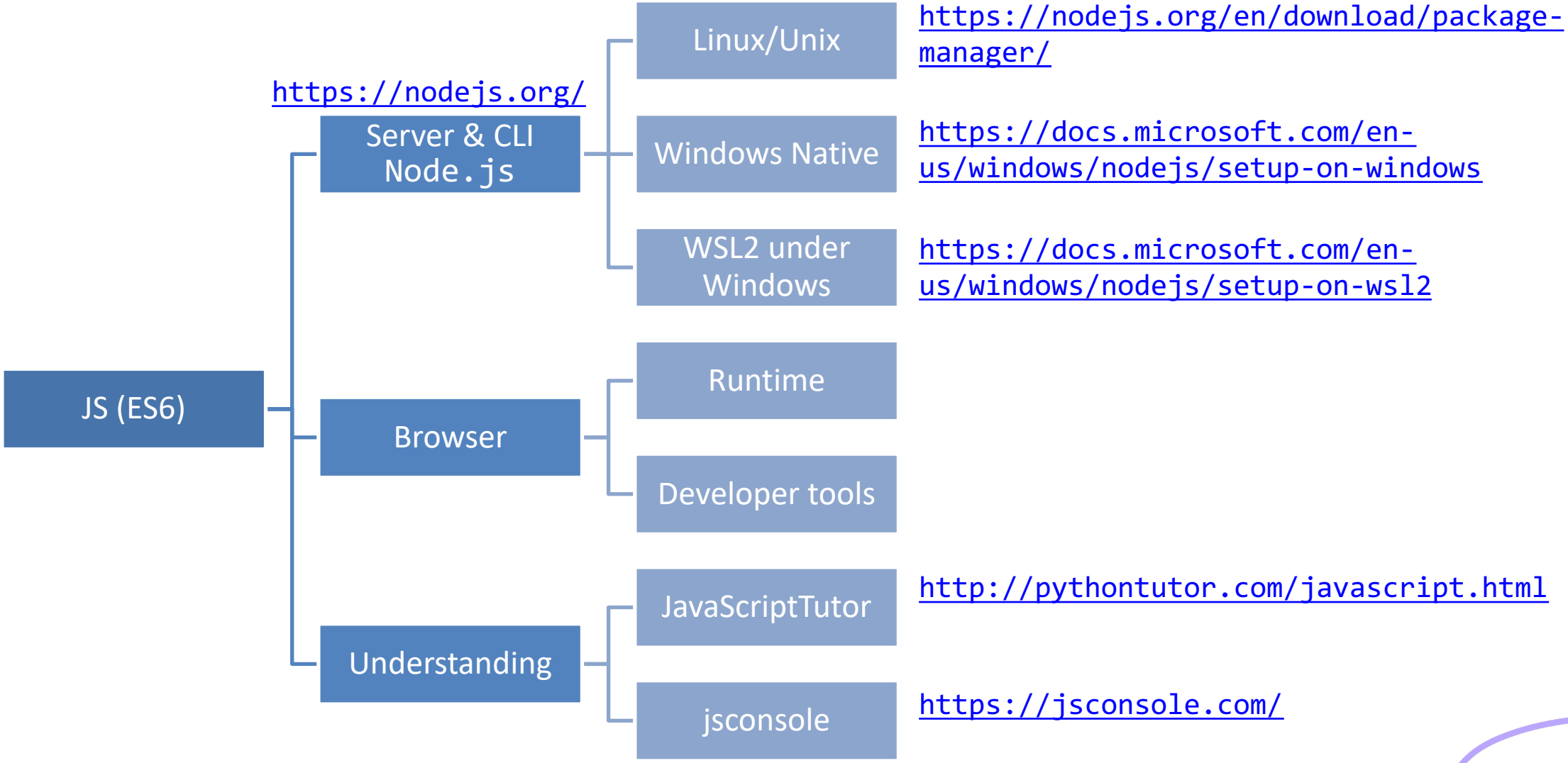
Deprecated. Not for use in new websites.

★ See implementation notes.

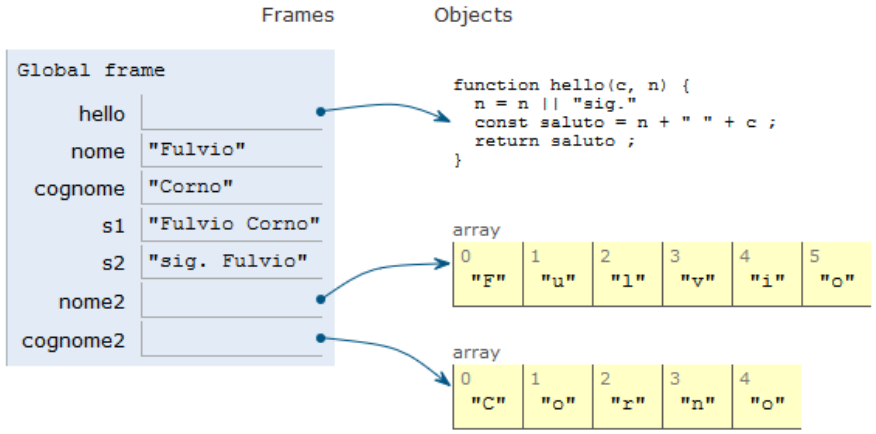
JS Compatibility

- JS is *backwards-compatible*
  - once something is accepted as valid JS, there will not be a future change to the language that causes that code to become invalid JS
  - TC39 members: "we don't break the web!"
- JS is not *forwards-compatible*
  - new additions to the language will not run in an older JS engine and may crash the program
- **strict mode** was introduced to disable very old (and dangerous) semantics
- Supporting multiple versions is achieved by:
  - *Transpiling* – Babel (https://babeljs.io) converts from newer JS syntax to an equivalent older syntax
  - *Polyfilling* – user- (or library-)defined functions and methods that “fill” the lack of a feature by implementing the newest available one

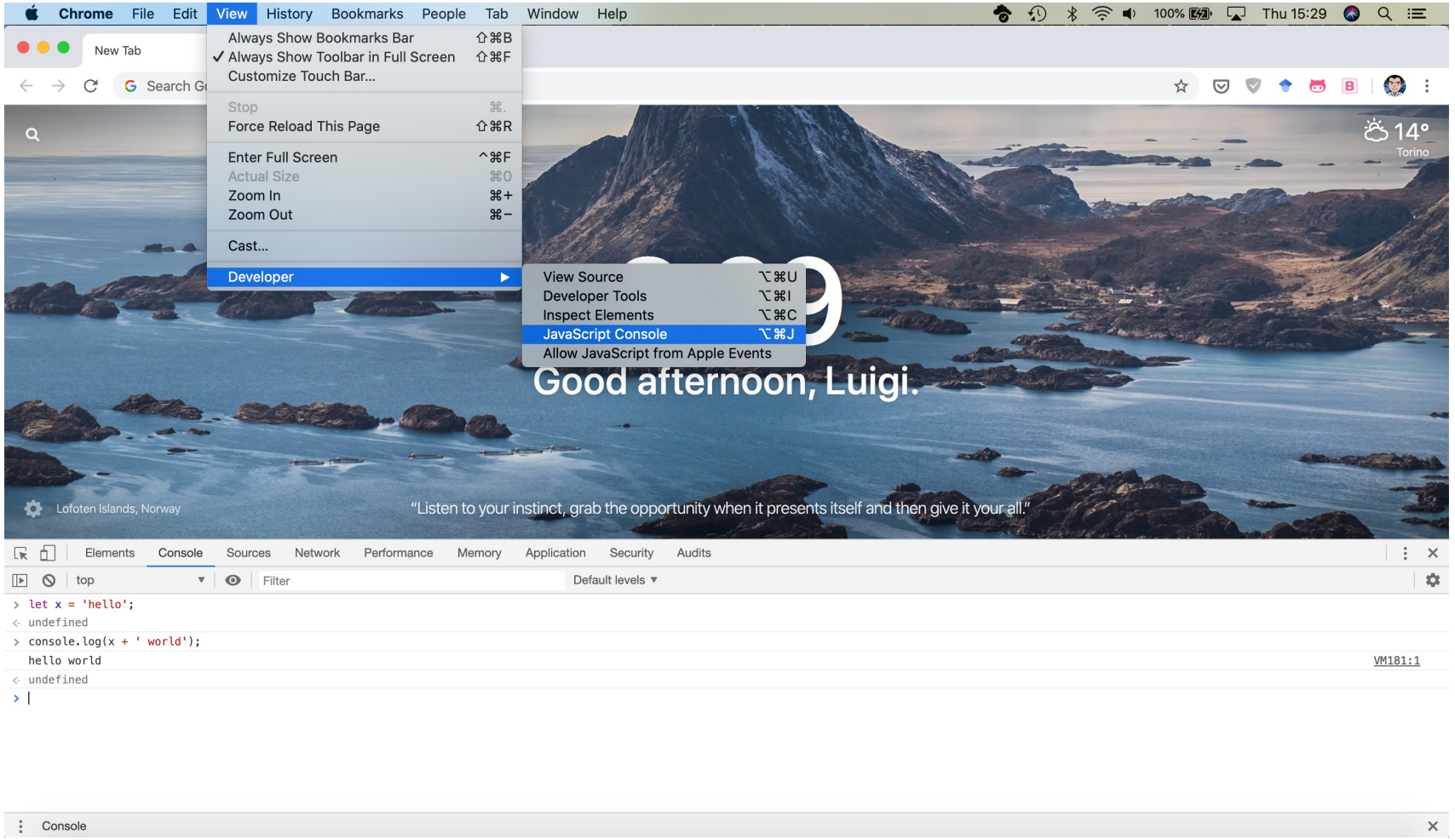
JS Execution Environments



JavaScriptTutor



Browser and JS console



JavaScript – The language of the Web

LANGUAGE STRUCTURE

Lexical structure

- One File = One JS program
  - Each file is loaded independently and
  - Different files/programs may communicate through *global state*
  - The “module” mechanism extends that (provides state sharing in a clean way)
- The file is entirely *parsed*, and then *executed* from top to bottom
- Relies on a *standard library*
  - and many additional *APIs* provided by the execution environment

Lexical structure

```
> let öööö = 'appalled'
> öööö
'appalled'
```

- JavaScript is written in Unicode (do not abuse), so it also supports non-latin characters for names and strings
  - even emoji

```
> let x = '😇';
< undefined
> console.log(x);
  😇
```

- Semicolons (`;`) are not mandatory (automatically inserted)
- Case sensitive
- Comments as in C (`/*..*/` and `//`)
- Literals and identifiers (start with letter, $, _)
- Some reserved words
- C-like syntax

Semicolon (;)

- Argument of debate in the JS community
- JS inserts them as needed
  - When next line starts with code that breaks the current one
  - When the next line starts with }
  - When there is `return`, `break`, `throw`, `continue` on its own line
- Be careful that forgetting semicolon can lead to unexpected behavior
  - A newline does not automatically insert a semicolon: if the next line starts with (or [, it is interpreted as function call or array access
- We will **loosely** follow the Google style guide, so we will always insert semicolons after each statement
  - https://google.github.io/styleguide/jsguide.html

Strict Mode

```
// first line of file
"use strict" ;
// always!!
```

- Directive introduced in ES5: `"use strict" ;`
  - Compatible with older version (it is just a string)
- Code is executed in *strict mode*
  - This fixes some important language deficiencies and provides stronger error checking and security
  - Examples:
    - fixes mistakes that make it difficult for JavaScript engines to perform optimizations: strict mode code can sometimes be made to run faster than identical code that's not strict mode
    - eliminates some JavaScript silent errors by changing them to throw errors
    - functions invoked as functions and not as methods of an object have `this` undefined
    - cannot define 2 or more properties or function parameters with the same name
    - no octal literals (base 8, starting with 0)
    - …

Mozilla Developer Network: The Script element
https://developer.mozilla.org/en-US/docs/Web/HTML/Element/script

JS in the browser

LOADING JS IN THE BROWSER

Loading JavaScript In The Browser

- JS must be loaded from an HTML document
- `<script>` tag
  - Inline

```
...
<script>
alert('Hello');
</script>
...
```

  - External

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

https://developer.mozilla.org/en-US/docs/Web/HTML/Element/script

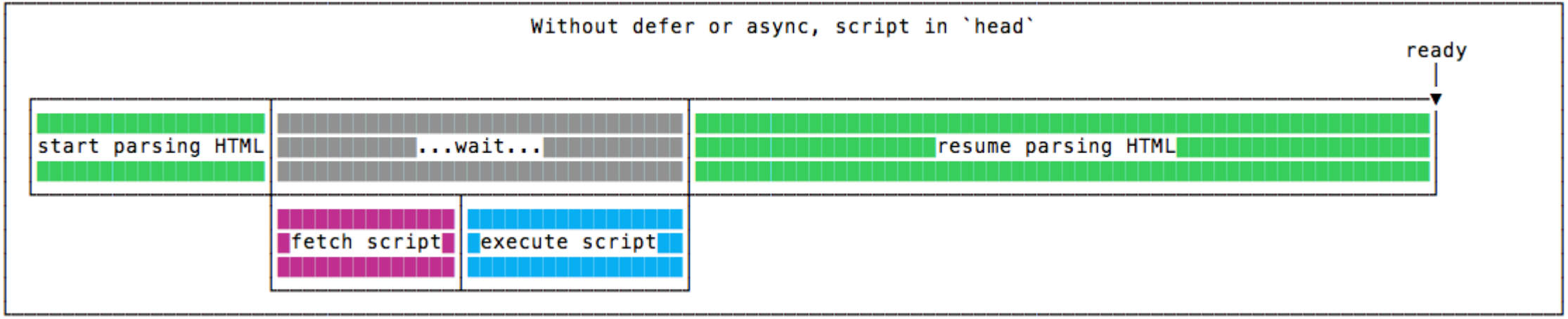
Where To Insert The <script> Tag?

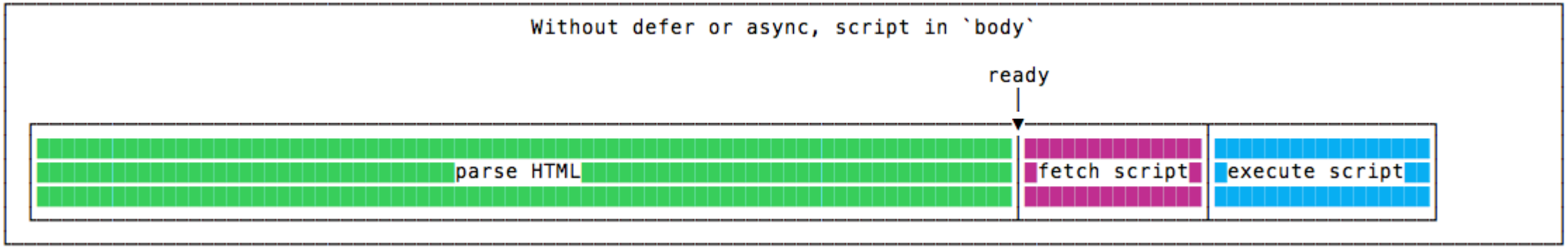
- In the <head> section
  - "clean" / "textbook" solution
  - Very **inefficient**: HTML processing is stopped until the script is loaded and executed
  - Quite **inconvenient**: the script executes when the document's DOM does not exist yet
  - *But*: see after!
- Just before the end of the document
  - More efficient than the "textbook" solution

```
<!DOCTYPE html>
<html>
  <head>
    <title>Loading a script</title>
    <script src="script.js"></script>
  </head>
  <body>
    ...
  </body>
</html>
```

```
<!DOCTYPE html>
<html>
  <head>
    <title>Loading a script</title>
  </head>
  <body>
    ...
    <script src="script.js"></script>
  </body>
</html>
```

Performance Comparison In Loading JS



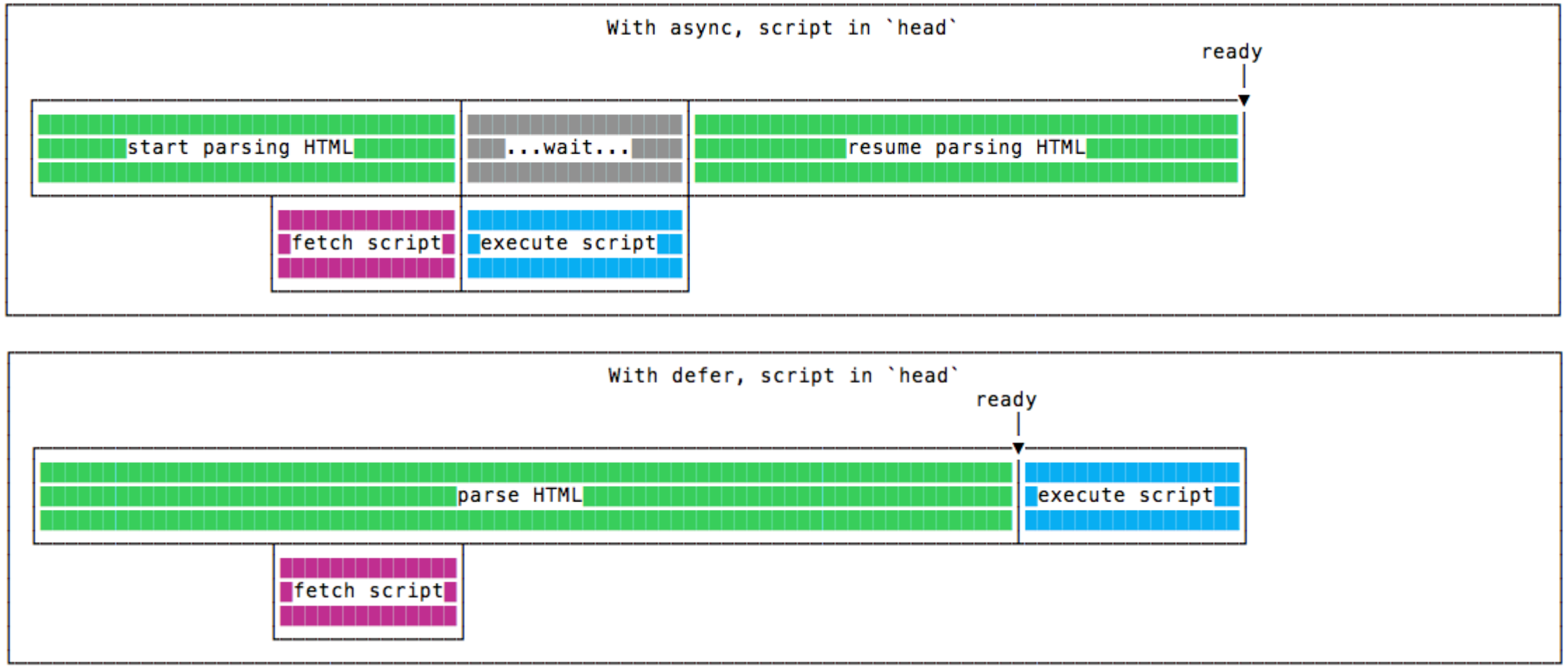


https://flaviocopes.com/javascript-async-defer/

New Loading Attributes

- `<script async src="script.js"></script>`
  - Script will be fetched in parallel to parsing and evaluated as soon as it is available
  - Not immediately executed, not blocking
- `<script defer src="script.js"></script>` (***preferred***)
  - Indicate to a browser that the script is meant to be executed after the document has been parsed, but before firing `DOMContentLoaded` (that will wait until the script is finished)
  - Guaranteed to execute in the order they are loaded
- Both should be placed in the `<head>` of the document

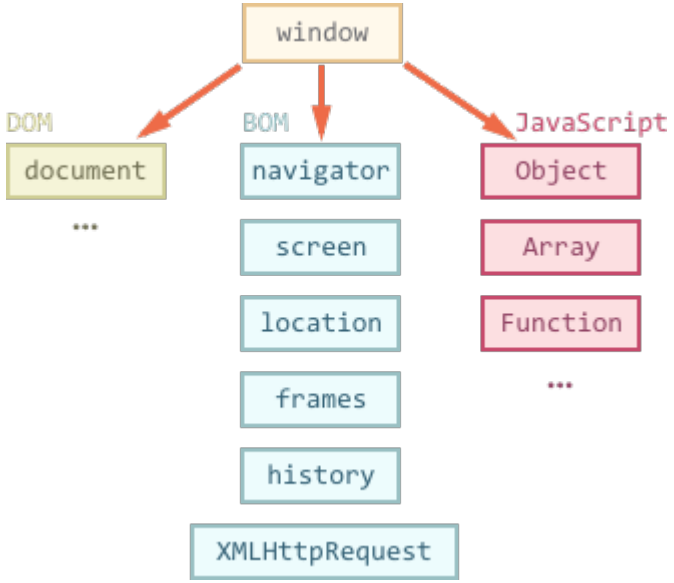
defer vs. async



https://flaviocopes.com/javascript-async-defer/

Where Does The Code Run?

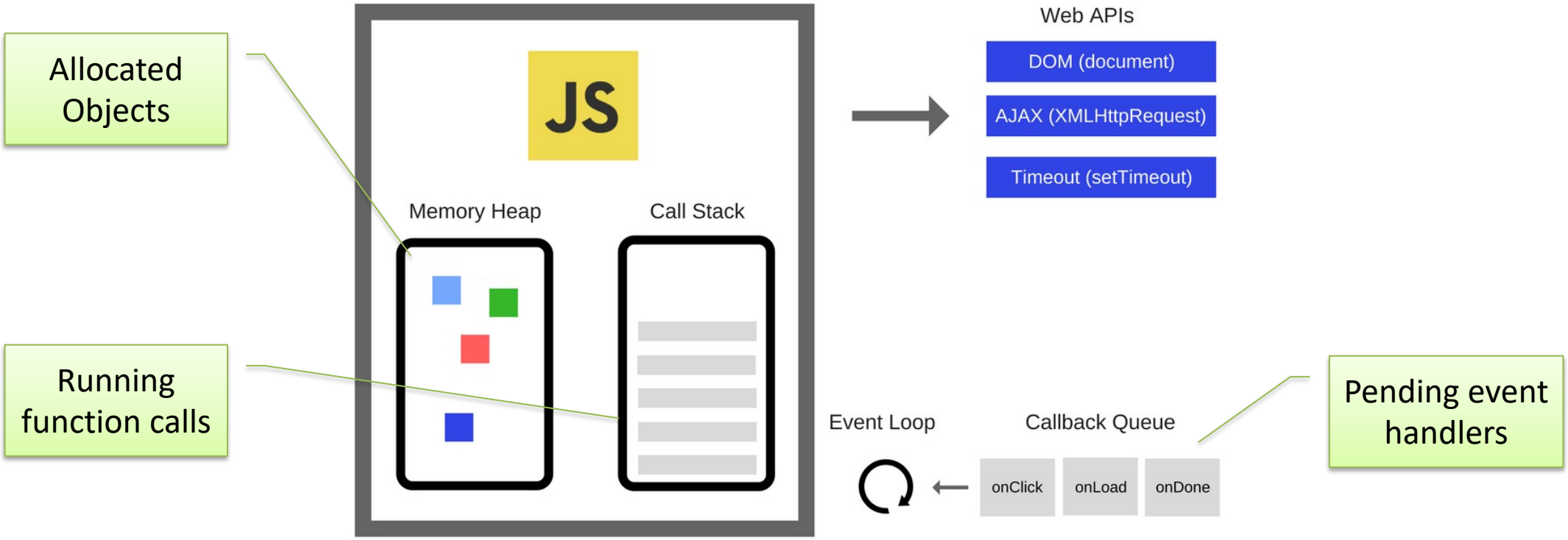
- Loaded and run in the browser *sandbox*
- Attached to a *global context:* the `window` object
- May access only a limited set of APIs
  - JS Standard Library
  - Browser objects (BOM)
  - Document objects (DOM)
- Multiple `<script>`s are independent
  - They all access the same global scope
  - To have structured collaboration, *modules* are needed



Events and Event Loop

- Most phases of processing and interaction with a web document will generate Asynchronous *Events* (100's of different types)
- Generated events may be handled by:
  - Pre-defined behaviors (by the browser)
  - User-defined *event handlers* (in your JS)
  - Or just ignored, if no event handler is defined
- But JavaScript is single-threaded
  - Event handling is *synchronous* and is based on an *event loop*
  - Event handlers are queued on a *Message Queue*
  - The Message Queue is polled when the main thread is idle

Execution Environment



Event Loop

- During code execution you may
  - Call functions → the function call is pushed to the call stack
  - Schedule events → the call to the event handler is put in the Message Queue
    - Events may be scheduled also by external events (user actions, I/O, network, timers, …)
- At any step, the JS interpreter:
  - If the call stack is not empty, pop the top of the call stack and executes it
  - If the call stack is empty, pick the head of the Message Queue and executes it
- A function call / event handler is **never** interrupted
  - Avoid blocking code!

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

https://nodejs.org/en/docs/guides/event-loop-timers-and-nexttick/#what-is-the-event-loop

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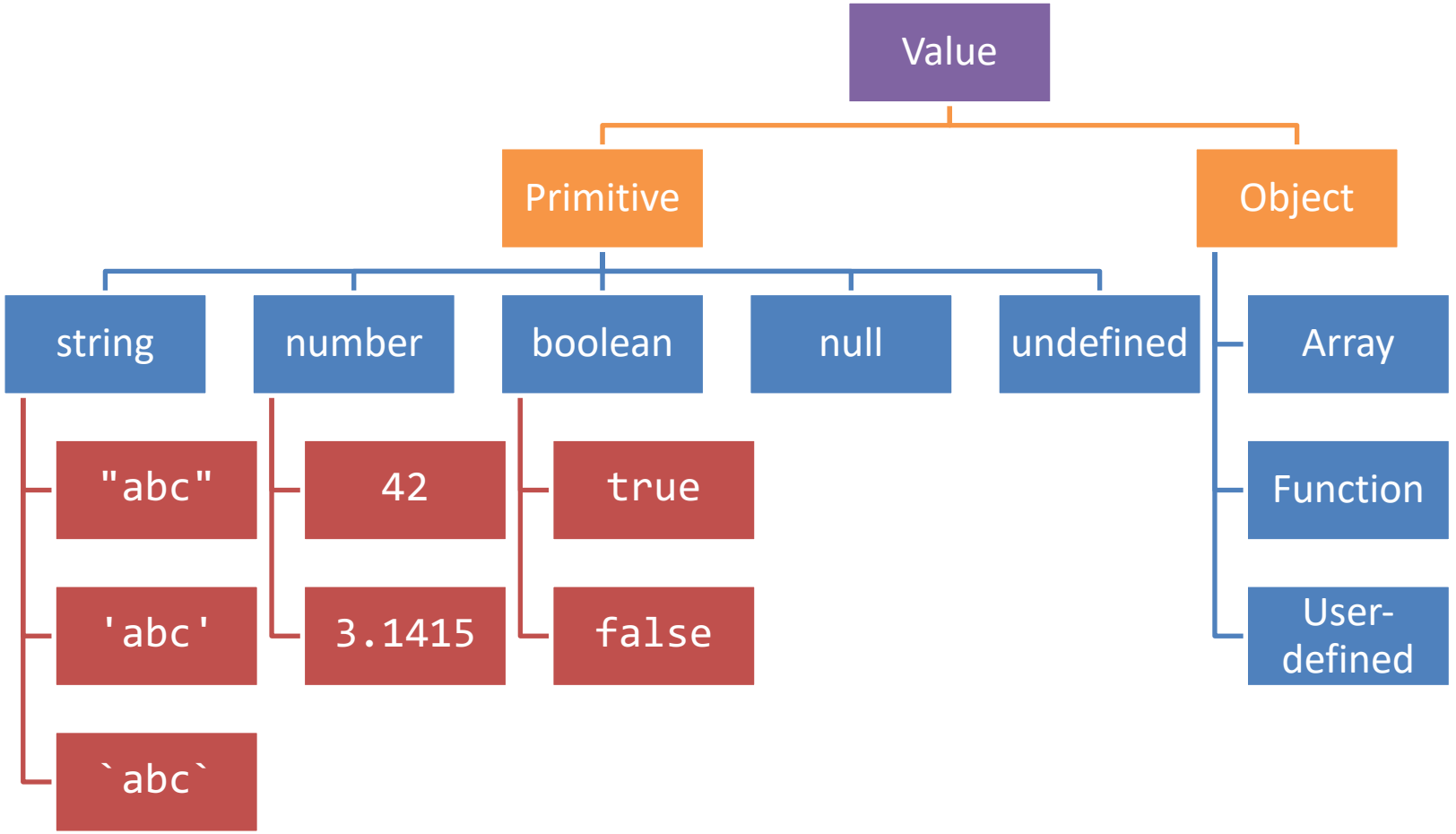
TYPES AND VARIABLES

Values and Types

Values have types.
Variables don't.



Boolean, true-*truthy*, false-*falsy*, comparisons

- 'boolean' type with literal values: `true`, `false`
- When converting to boolean
  - The following values are 'falsy'
    - `0`, `-0`, `NaN`, `undefined`, `null`, `''` (empty string)
  - Every other value is 'truthy'
    - `3`, `'false'`, `[]` (empty array), `{}` (empty object)
- Booleans and Comparisons
  - `a == b` *// convert types and compare results*
  - `a === b` *// inhibit automatic type conversion and compare results*

```
> Boolean(3)
true
> Boolean('')
false
> Boolean(' ')
true
```

Number

- No distinction between integers and reals
- Automatic conversions according to the operation

- There is also a distinct type "`BigInt`" (*ES11, July 2020*)
  - an arbitrary-precision integer, can represent 2^{53} numbers
  - `123456789n`
  - `With suffix ‘n’`

Special values

- **`undefined`**: variable declared but not initialized
  - Detect with: `typeof variable === 'undefined'`
  - `void x` always returns undefined
- **`null`**: an empty value
- Null and Undefined are called *nullish values*

- **`NaN`** (Not a Number)
  - It is actually a number
  - Invalid output from arithmetic operation or parse operation

Variables

```
> v = 7 ;
7
> v = 'hi' ;
'hi'
```

- Variables are ***pure*** *references*: they refer to a *value*
- The same variable may refer to different values (even of different types) at different times

- Declaring a variable:
  - **`let`**
  - **`const`**
  - `var`

```
> let a = 5
> const b = 6
> var c = 7
> a = 8
8
> b = 9
Thrown:
TypeError: Assignment to
constant variable.
> c = 10
10
```

Variable declarations

Declarator	Can reassign?	Can re-declare?	Scope	Hoisting *	Note
`let`	Yes	No	Enclosing block {…}	No	***Preferred***
`const`	No §	No	Enclosing block {…}	No	***Preferred***
`var`	Yes	Yes	Enclosing function, or global	Yes, to beginning of function or file	*Legacy, beware its quirks, try not to use*
None (implicit)	Yes	N/A	Global	Yes	*Forbidden in strict mode*

§ Prevents reassignment (a=2), does not prevent changing the value of the referred object (`a.b=2`)

* Hoisting = "lifting up" the definition of a variable (not the initialization!) to the top of the current scope (e.g., the file or the function)

Scope

```
"use strict" ;

let a = 1 ;
const b = 2 ;
let c = true ;

let a = 5 ; // SyntaxError: Identifier 'a' has already been declared
```

Scope

Typically, you don't create a new scope in this way!

```
"use strict" ;

let a = 1 ;
const b = 2 ;
let c = true ;

{ // creating a new scope...
   let a = 5 ;
   console.log(a) ;
}

console.log(a) ;
```

Each { } is called a **block**. '`let`' and '`const`' variables are *block-scoped*.

They exist only in their defined and inner scopes.

JavaScript: The Definitive Guide, 7th Edition
Chapter 2. Types, Values, and Variables
Chapter 3. Expressions and Operators

Mozilla Developer Network
JavaScript Guide » Expressions and operators

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EXPRESSIONS

Operators

- Assignment operators
- Comparison operators
- Arithmetic operators
- Bitwise operators
- Logical operators
- String operators
- Conditional (ternary) operator
- Comma operator
- Unary operators
- Relational operators

Full reference and operator precedence: https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Operators/Operator_Precedence#Table

Assignment

- `let variable = expression ;` // declaration with initialization
- `variable = expression ;` // reassignment

Name	Shorthand operator	Meaning
Assignment	`x = y`	`x = y`
Addition assignment	`x += y`	`x = x + y`
Subtraction assignment	`x -= y`	`x = x - y`
Multiplication assignment	`x *= y`	`x = x * y`
Division assignment	`x /= y`	`x = x / y`
Remainder assignment	`x %= y`	`x = x % y`
Exponentiation assignment	`x **= y`	`x = x ** y`
Left shift assignment	`x <<= y`	`x = x << y`
Right shift assignment	`x >>= y`	`x = x >> y`
Unsigned right shift assignment	`x >>>= y`	`x = x >>> y`
Bitwise AND assignment	`x &= y`	`x = x & y`
Bitwise XOR assignment	`x ^= y`	`x = x ^ y`
Bitwise OR assignment	`x |= y`	`x = x | y`

Comparison operators

Operator	Description	Examples returning true

Equal (`==`)	Returns `true` if the operands are equal.	`3 == var1`
		`"3" == var1`
		
		`3 == '3'`

Not equal (`!=`)	Returns `true` if the operands are not equal.	`var1 != 4` `var2 != "3"`
Strict equal (`===`)	Returns `true` if the operands are equal and of the same type. See also `Object.is` and sameness in JS.	`3 === var1`
Strict not equal (`!==`)	Returns `true` if the operands are of the same type but not equal, or are of different type.	`var1 !== "3"` `3 !== '3'`
Greater than (`>`)	Returns `true` if the left operand is greater than the right operand.	`var2 > var1` `"12" > 2`
Greater than or equal (`>=`)	Returns `true` if the left operand is greater than or equal to the right operand.	`var2 >= var1` `var1 >= 3`
Less than (`<`)	Returns `true` if the left operand is less than the right operand.	`var1 < var2` `"2" < 12`
Less than or equal (`<=`)	Returns `true` if the left operand is less than or equal to the right operand.	`var1 <= var2` `var2 <= 5`

Comparing Objects

- Comparison between objects with == or === compares the *references* to objects
  - True only if they are *the same object*
  - False if they are *identical objects*
- Comparison with < > <= >= first converts the object (into a Number, or more likely a String), and then compares the values
  - It works, but may be unpredictable, depending on the string format

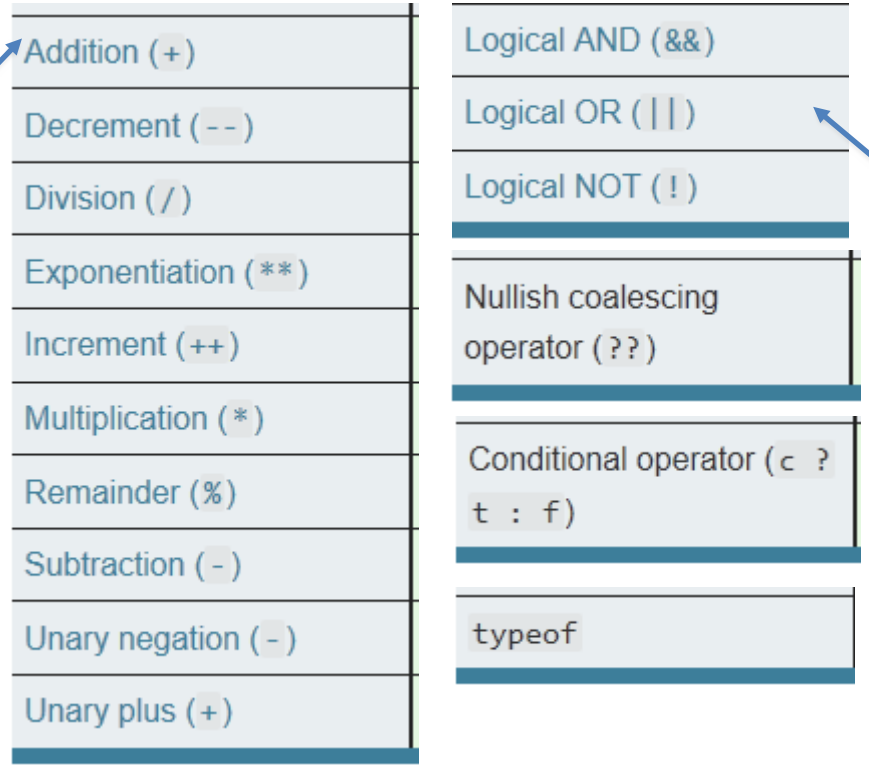
```
> a={x:1}
{ x: 1 }

> b={x:1}
{ x: 1 }

> a===b
false

> a==b
false
```

Logical operators

Operator	Usage	Description
Logical AND (`&&`)	`expr1 && expr2`	Returns `expr1` if it can be converted to `false`; otherwise, returns `expr2`. Thus, when used with Boolean values, `&&` returns `true` if both operands are true; otherwise, returns `false`.
Logical OR (`||`)	`expr1 || expr2`	Returns `expr1` if it can be converted to `true`; otherwise, returns `expr2`. Thus, when used with Boolean values, `||` returns `true` if either operand is true; if both are false, returns `false`.
Logical NOT (`!`)	`!expr`	Returns `false` if its single operand that can be converted to `true`; otherwise, returns `true`.

Common operators

Or string concatenation



Useful idiom:
a||b
if a then a else b
(a, with default b)

Mathematical functions (`Math` global object)

- **Constants**: `Math.E`, `Math.LN10`, `Math.LN2`, `Math.LOG10E`, `Math.LOG2E`, `Math.PI`, `Math.SQRT1_2`, `Math.SQRT2`
- **Functions**: `Math.abs()`, `Math.acos()`, `Math.acosh()`, `Math.asin()`, `Math.asinh()`, `Math.atan()`, `Math.atan2()`, `Math.atanh()`, `Math.cbrt()`, `Math.ceil()`, `Math.clz32()`, `Math.cos()`, `Math.cosh()`, `Math.exp()`, `Math.expm1()`, `Math.floor()`, `Math.fround()`, `Math.hypot()`, `Math.imul()`, `Math.log()`, `Math.log10()`, `Math.log1p()`, `Math.log2()`, `Math.max()`, `Math.min()`, `Math.pow()`, `Math.random()`, `Math.round()`, `Math.sign()`, `Math.sin()`, `Math.sinh()`, `Math.sqrt()`, `Math.tan()`, `Math.tanh()`, `Math.trunc()`

JavaScript: The Definitive Guide, 7th Edition
Chapter 4. Statements

Mozilla Developer Network
JavaScript Guide » Control Flow and Error Handling
JavaScript Guide » Loops and Iteration

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CONTROL STRUCTURES

Conditional statements

```
if (condition) {
  statement_1;
} else {
  statement_2;
}
```

if truthy (beware!)

```
if (condition_1) {
  statement_1;
} else if (condition_2) {
  statement_2;
} else if (condition_n) {
  statement_n;
} else {
  statement_last;
}
```

May also be a string

```
switch (expression) {
  case label_1:
    statements_1
    [break;]
  case label_2:
    statements_2
    [break;]
    …
  default:
    statements_def
    [break;]
}
```

Loop statements

```
for ([initialExpression]; [condition]; [incrementExpression]) {
  statement ;
}
```

Usually declares loop variable

May use `break;` or `continue;`

```
do {
  statement ;
} while (condition);
```

```
while (condition) {
  statement ;
}
```

Special '`for`' statements

Preferred

```
for (variable in object) {
  statement ;
}
```

- Iterates the variable over all the enumerable **properties** of an **object**
- Do not use to traverse an array (use numerical indexes, or for-of)

```
for( let a in {x: 0, y:3}) {
     console.log(a) ;
}
```

```
x
y
```

```
for (variable of iterable) {
  statement ;
}
```

- Iterates the variable over all values of an *iterable object* (including Array, Map, Set, string, arguments …)
- Returns the *values*, not the keys

```
for( let a of [4,7]) {
     console.log(a) ;
}
```

```
4
7
```

```
for( let a of "hi" ) {
     console.log(a) ;
}
```

```
h
i
```

Other iteration methods

- Functional programming (strongly supported by JS) allows other methods to iterate over a collection (or any iterable object)
  - `a.forEach()`
  - `a.map()`
- We will not cover these methods in this course

Exception handling

```
try {
  statements ;
} catch(e) {
  statements ;
}
```

```
try {
  statements ;
} catch(e) {
  statements ;
} finally {
  statements ;
}
```

Exception object

```
throw object ;
```

```
EvalError
RangeError
ReferenceError
SyntaxError
TypeError
URIError
DOMException
```

Contain fields: name, message

Executed in any case, at the end of try and catch blocks

JavaScript: The Definitive Guide, 7th Edition
Chapter 6. Arrays

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JavaScript Guide » Indexed Collections

JavaScript – The language of the Web

ARRAYS

Arrays

- Rich of functionalities
- Elements do not need to be of the same type
- Simplest syntax: `[ ]`
- Property `.length`
- Distinguish between methods that:
  - Modify the array (**in-place**)
  - Return a **new** array

Creating an array

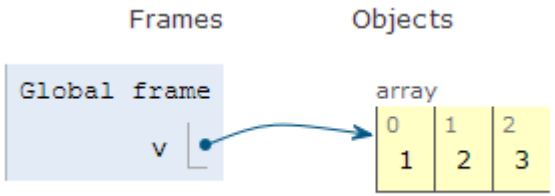
Elements are indexed at positions 0...length-1

Do not access elements outside range

```
let v = [] ;
```

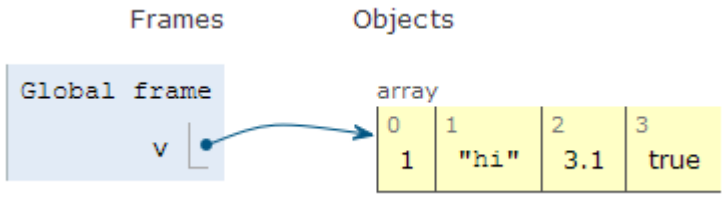
```
let v = [1, 2, 3] ;
```

```
let v = Array.of(1, 2, 3) ;
```




```
let v = [1, "hi", 3.1, true];
```

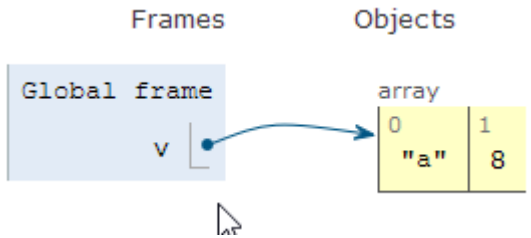
```
let v = Array.of(1, "hi",
3.1, true) ;
```



Adding elements

`.lenght` adjusts automatically

```
let v = [] ;
v[0] = "a" ;
v[1] = 8 ;
v.length // 2
```

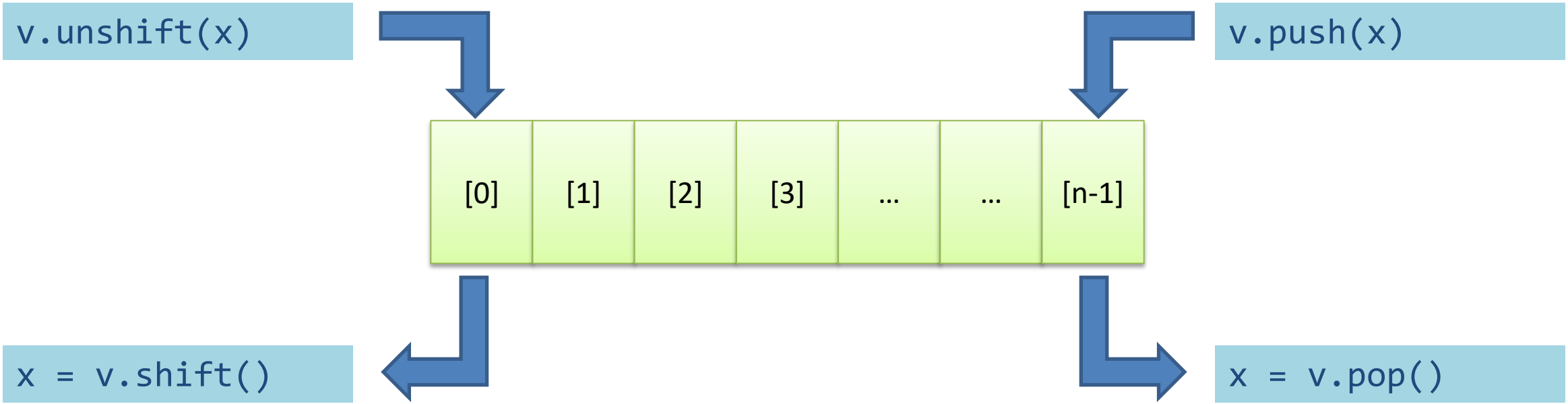



```
let v = [] ;
v.push("a") ;
v.push(8) ;
v.length // 2
```

`.push()` adds at the end of the array

`.unshift()` adds at the beginning of the array

Adding and Removing from arrays (in-place)



Copying arrays

```
let v = [] ;
v[0] = "a" ;
v[1] = 8 ;

let alias = v ;
alias[1] = 5 ;
```

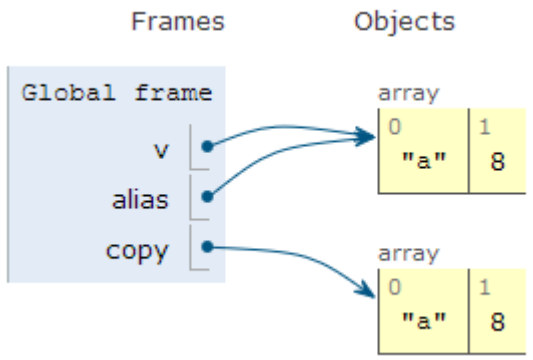
```
> console.log(v);
[ 'a', 5 ]
undefined
> console.log(alias);
[ 'a', 5 ]
undefined
```

?

Copying arrays

```
let v = [] ;
v[0] = "a" ;
v[1] = 8 ;

let alias = v ;
let copy = Array.from(v) ;
```



Array.from creates a *shallow copy*

Creates an array from any iterable object

Iterating over Arrays

Preferred

- Iterators: `for ... of, for (..;..;..)`
- Iterators: `forEach(f)`
  - f is a function that processes the element
- Iterators: `every(f), some(f)`
  - f is a function that returns true or false
- Iterators that return a new array: `map(f), filter(f)`
  - `f` works on the element of the array passed as parameter
- Reduce: exec a callback function on all items to progressively compute a result

Functional style

Main array methods

- `.concat()`
  - joins two or more arrays and returns a **new** array.
- `.join(delimiter = ',')`
  - joins all elements of an array into a (**new**) string.
- `.slice(start_index, upto_index)`
  - extracts a section of an array and returns a **new** array.
- `.splice(index, count_to_remove, addElement1, addElement2, ...)`
  - removes elements from an array and (optionally) replaces them, **in place**
- `.reverse()`
  - transposes the elements of an array, **in place**
- `.sort()`
  - sorts the elements of an array **in place**
- `.indexOf(searchElement[, fromIndex])`
  - searches the array for searchElement and returns the **index** of the first match
- `.lastIndexOf(searchElement[, fromIndex])`
  - like indexOf, but starts at the end
- `.includes(valueToFind[, fromIndex])`
  - search for a certain value among its entries, returning true or false

Destructuring assignment

- Value of the right-hand side of equal signal are extracted and stored in the variables on the left

```
let [x,y] = [1,2];
[x,y] = [y,x]; // swap

var foo = ['one', 'two', 'three'];
var [one, two, three] = foo;
```

- Useful especially with passing and returning values from functions

```
let [x,y] = toCartesian(r,theta);
```

Spread operator (3 dots: . . .)

- Expands an interable object in its parts, when the syntax requires a comma-separated list of elements

```
let [x, ...y] = [1,2,3,4]; // we obtain y == [2,3,4]

const parts = ['shoulders', 'knees'];
const lyrics = ['head', ...parts, 'and', 'toes']; // ["head", "shoulders",
"knees", "and", "toes"]
```

- Works on the left- and right-hand side of the assignment

Curiosity

- Copy by value:
  - `const b = Array.from(a)`
- Can be emulated by
  - `const b = Array.of(...a)`
  - `const b = [...a]`

Frequent idiom

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Chapter 2. Types, Values, and Variables

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JavaScript – The language of the Web

STRINGS

Strings in JS

- A string is an **immutable** ordered sequence of Unicode(*) characters
- The length of a string is the number of characters it contains (not bytes)
- JavaScript's strings use zero-based indexing
  - The empty string is the string of length 0
- JavaScript does not have a special type that represents a single character (use length-1 strings).
- String literals may be defined with `'abc'` or `"abc"`
  - Note: when dealing with JSON parsing, only `" "` can be correctly parsed

String operations

- All operations always return **new** strings
  - Consequence of immutability
- `s[3]`: indexing
- `s1 + s2`: concatenation
- `s.length`: number of characters
  - Note: `.length` , not ~~`.length()`~~

String methods

Method	Description
`charAt`, `charCodeAt`, `codePointAt`	Return the character or character code at the specified position in string.
`indexOf`, `lastIndexOf`	Return the position of specified substring in the string or last position of specified substring, respectively.
`startsWith`, `endsWith`, `includes`	Returns whether or not the string starts, ends or contains a specified string.
`concat`	Combines the text of two strings and returns a new string.
`fromCharCode`, `fromCodePoint`	Constructs a string from the specified sequence of Unicode values. This is a method of the String class, not a String instance.
`split`	Splits a `String` object into an array of strings by separating the string into substrings.
`slice`	Extracts a section of a string and returns a new string.
`substring`, `substr`	Return the specified subset of the string, either by specifying the start and end indexes or the start index and a length.
`match`, `matchAll`, `replace`, `search`	Work with regular expressions.
`toLowerCase`, `toUpperCase`	Return the string in all lowercase or all uppercase, respectively.
`normalize`	Returns the Unicode Normalization Form of the calling string value.
`repeat`	Returns a string consisting of the elements of the object repeated the given times.
`trim`	Trims whitespace from the beginning and end of the string.

Template literals

- Strings included in `backticks` can embed expressions delimited by ${}
- The value of the expression is *interpolated* into the string

```
let name = "Bill";
let greeting = `Hello ${ name }.`;
// greeting == "Hello Bill."
```

- Very useful and quick for string formatting
- Template literals may also span multiple lines

JavaScript: The Definitive Guide, 7th Edition
Chapter 5. Objects

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- Learn web development JavaScript » Dynamic client-side scripting » Introducing JavaScript objects
- Web technology for developers » JavaScript » JavaScript reference » Standard built-in objects » Object
- Web technology for developers » JavaScript » JavaScript reference » Expressions and operators » in operator

JavaScript – The language of the Web

OBJECTS

Big Warnings

- In JavaScript, Objects may exist without Classes
  - Usually, Objects are created directly, without deriving them from a Class definition
- In JavaScript, Objects are dynamic
  - You may add, delete, redefine a *property* at any time
  - You may add, delete, redefine a *method* at any time
- In JavaScript, there are no access control methods
  - Every property and every method is always public (private/protected don't exist)
- There is no real difference between properties and methods (because of how JS functions work)

Object

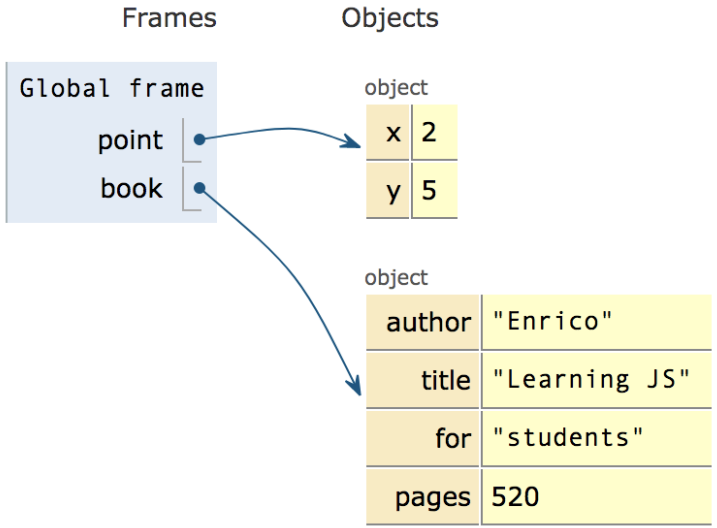
- An object is an unordered collection of properties
  - Each property has a **name** (key), and a **value**
- You store and retrieve *property values*, through the *property names*
- Object creation and initialization:

```
let point = { x: 2, y: 5 };

let book = {
  author : "Enrico",
  title : "Learning JS",
  for: "students",
  pages: 520,
};
```

Object literals syntax:

```
{"name": value,
"name": value, }
        or:
 {name: value,
 name: value, }
```



Object Properties

Property names are …

- Identified as a string
- Must be unique in each object
- Created at object initialization
- Added after object creation
  - With assignment
- Deleted after object creation
  - With `delete` operator

Property values are …

- Reference to any JS value
- Stored inside the object
- May be primitive types
- May be arrays, other objects, …
  - Beware: the object stores the reference, the value is *outside*
- May also be functions (*methods*)

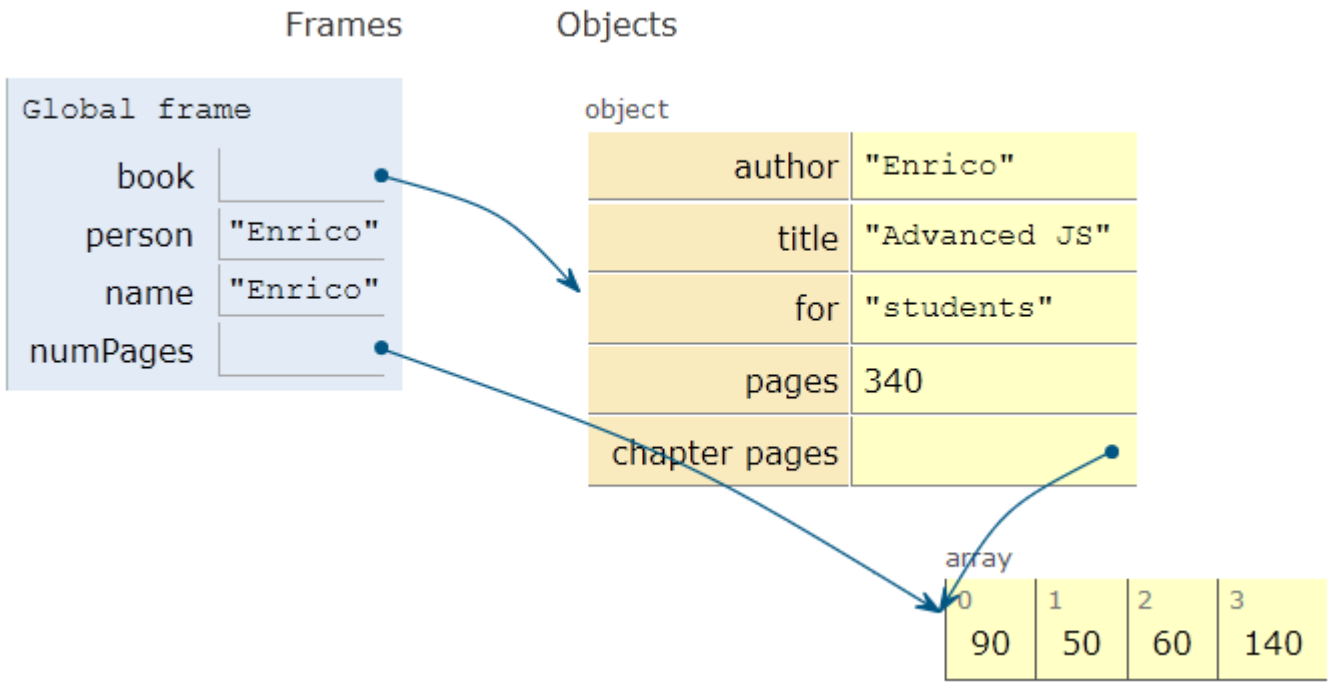
Accessing properties

- Dot (.) or square brackets [ ] notation

The . dot notation and omitting the quotes are allowed **when the property name is a valid identifier, only**.
`book.title` or `book['title']`
`book['my title']` and not ~~`book.my title`~~

```
let book = {
  author : "Enrico",
  title : "Learning JS",
  for: "students",
  pages: 340,
  "chapter pages": [90,50,60,140]
};

let person = book.author;
let name = book["author"];
let numPages =
    book["chapter pages"];
book.title = "Advanced JS";
book["pages"] = 340;
```



Objects as associative arrays

- The [ ] syntax looks like array access, but the index is *a string*
  - Generally known as *associative arrays*
- Setting a non-existing property creates it:
  - `person["telephone"] = "0110901234";`
  - `person.telephone = "0110901234";`
- Deleting properties
  - `delete person.telephone;`
  - `delete person["telephone"];`

Computed property names

- Flexibility in creating object properties
  - `{[prop]:value}` -> creates an object with property name equal to *the value of the variable prop*
  - [] can contain more complex expressions: e.g., `i`-th line of an object with multiple "address" properties (address1, address2, …): `person["address"+i]`
    - **Using expressions is not recommended…**
- Beware of quotes:
  - `book["title"]` -> property called `title`
    - Equivalent to `book.title`
  - `book[title]` -> property called with the value of variable `title` (if exists)
    - If `title=="author"`, then equivalent to `book["author"]`
    - No equivalent in dot-notation

Property access errors

- If a property is not defined, the (attempted) access returns `undefined`
- If unsure, must check before accessing
  - Remember: `undefined` is *falsy*, you may use it in Boolean expressions

```
let surname = undefined;
if (book) {
    if (book.author) {
        surname = book.author.surname;
    }
}
```

```
surname = book && book.author && book.author.surname;
```

Iterating over properties

- `for .. in` iterates over the properties

```
for( let a in {x: 0, y:3}) {
     console.log(a) ;
}
```

```
x
y
```

```
let book = {
  author : "Enrico",
  pages: 340,
  chapterPages: [90,50,60,140],
};

for (const prop in book)
  console.log(`${prop} = ${book[prop]}`);
```

```
author = Enrico
pages = 340
chapterPages = 90,50,60,140
```

Iterating over properties

- All the (enumerable) properties names (keys) of an object can be accessed as an array, with:
  - `let keys = Object.keys(my_object) ;`

```
[ 'author', 'pages' ]
```

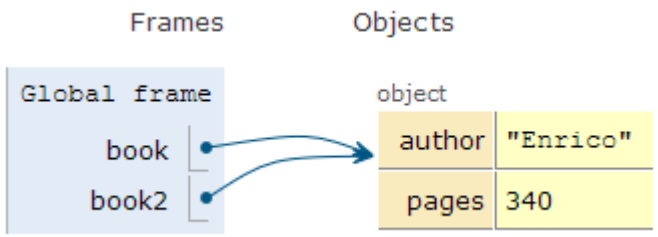
- All pairs [key, value] are returned as an array with:
  - `let keys_values = Object.entries(my_object)`

```
[ [ 'author', 'Enrico' ], [ 'pages', 340 ] ]
```

Copying objects

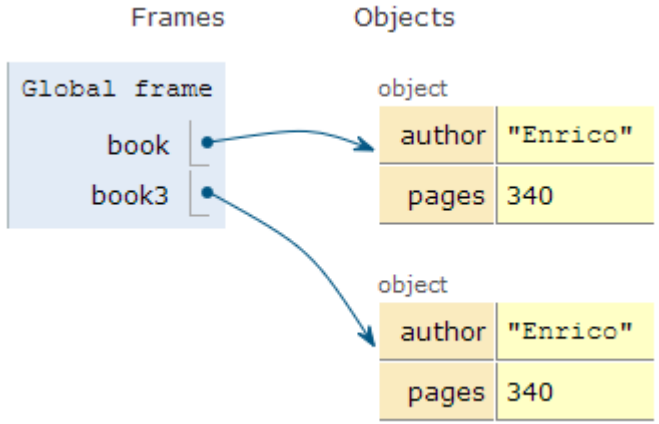
```
let book = {
  author : "Enrico",
  pages: 340,
};

let book2 = book;  // ALIAS
```




```
let book = {
  author : "Enrico",
  pages: 340,
};

let book3 =                  // COPY
   Object.assign({}, book);
```



Object.assign

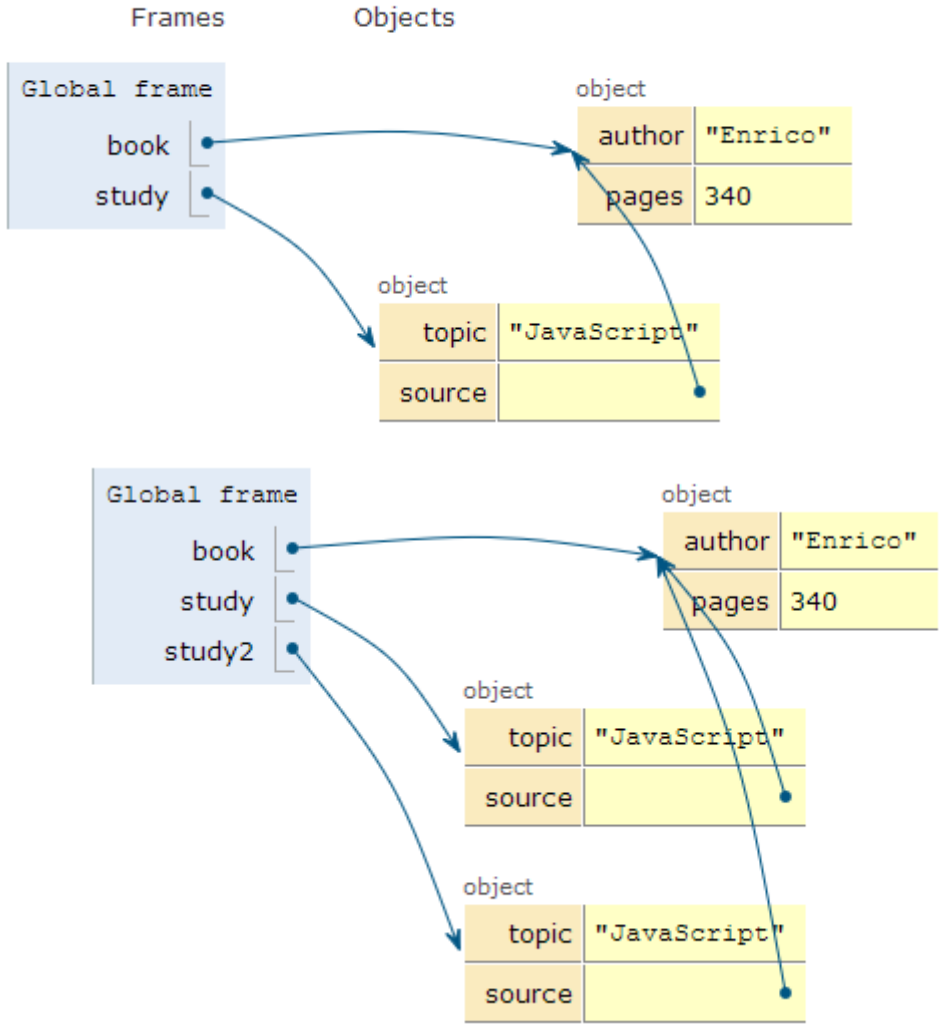
- `let new_object = Object.assign(target, source);`
- Assigns all the properties from the source object to the target one
- The target may be an existing object
- The target may be a new object: {}
- Returns the target object (after modification)

Beware! Shallow copy, only

```
let book = {
  author : "Enrico",
  pages: 340,
};

let study = {
  topic: "JavaScript",
  source: book,
};
```

```
let study2 = Object.assign({},
study);
```

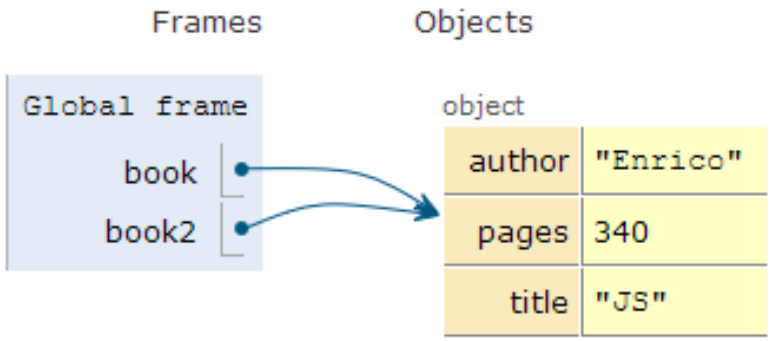


Merge properties (on existing object)

- `Object.assign(target, source, default values, ..);`

```
let book = {
  author : "Enrico",
  pages: 340,
};

let book2 = Object.assign(
 book, {title: "JS"}
);
```

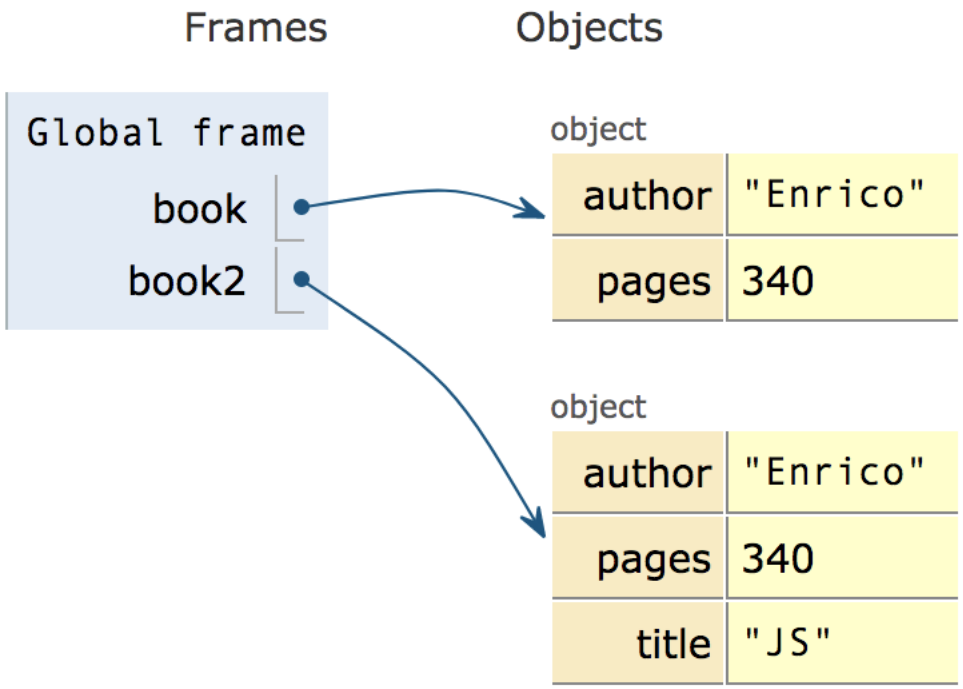


Merge properties (on new object)

- `Object.assign(target, source, default values, ..);`

```
let book = {
  author : "Enrico",
  pages: 340,
};

let book2 = Object.assign(
 {}, book, {title: "JS"}
);
```



Checking if properties exist

- Operator **`in`**
  - Returns true if property is in the object. Do not use with Array

```
let book = {
  author : "Enrico",
  pages: 340,
};

console.log('author' in book);
delete book.author;
console.log('author' in book);
```

```
true
false
```

```
const v=['a','b','c’];

console.log('b' in v);



console.log('PI' in Math);
```

```
false
true
```

Object creation (equivalent methods)

- By object literal: `const point = {x:2, y:5} ;`
- By object literal (empty object): `const point = {} ;`
- By constructor: `const point = new Object() ;`
- By object static method create:
  `const point = Object.create({x:2,y:5}) ;`
- Using a *constructor function*

Preferred

JavaScript: The Definitive Guide, 7th Edition
Chapter 7. Functions

JavaScript – The language of the Web

FUNCTIONS

Functions

- One of the most important elements in JavaScript
- Delimits a block of code with a private scope
- Can accept parameters and returns one value
  - Can also be an object
- Functions themselves **are objects** in JavaScript
  - They can be assigned to a variable
  - Can be passed as an argument
  - Used as a return value

Declaring functions: 3 ways

1) Classic

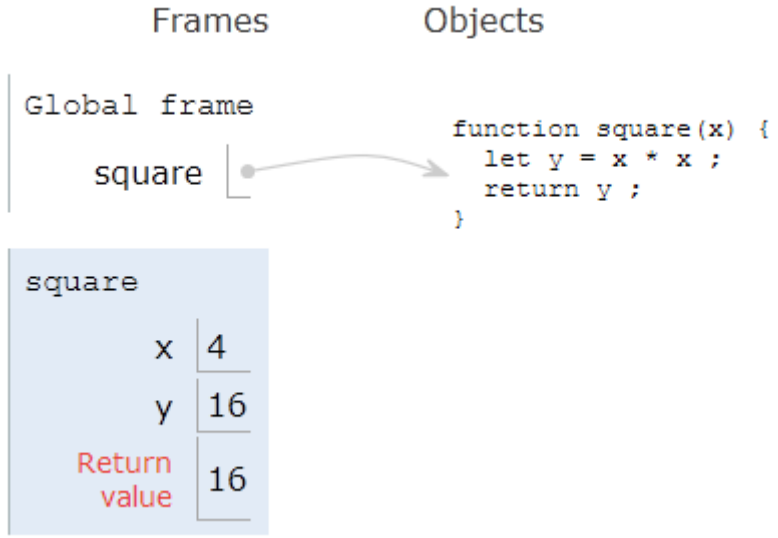
```
function do(params) {
  /* do something */
}
```

Classic functions

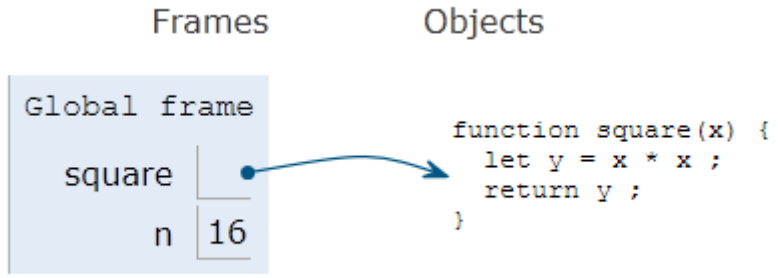
```
function square(x) {
  let y = x * x ;
  return y ;
}

let n = square(4) ;
```

During execution



After execution



Parameters

- Comma-separated list of parameter names
  - May assign a default value, e.g., `function(a, b=1) {}`
- Parameters are passed by-value
  - Copies of the reference to the object
- Parameters that are not passed in the function call get the value ‘`undefined`’
- Check missing/optional parameters with:
  - `if(p===undefined) p = default_value ;`
  - `p = p || default_value ;`

Variable number of parameters

- Syntax for functions with variable number of parameters, using the `...` operator (called “rest”)

```
function fun (par1, par2, ...arr) { }
```

- The “rest” parameter must be the last, and will deposit all extra arguments into an array

```
function sumAll(initVal, ...arr) {
  let sum = initVal;
  for (let a of arr) sum += a;
  return sum;
}
sumAll(0, 2, 4, 5); // 11
```

Declaring functions: 3 ways

1) Classic

```
function do(params) {
  /* do something */
}
```

2a) Function expression

```
const fn = function(params) {
  /* do something */
}
```

2b) Named function expression

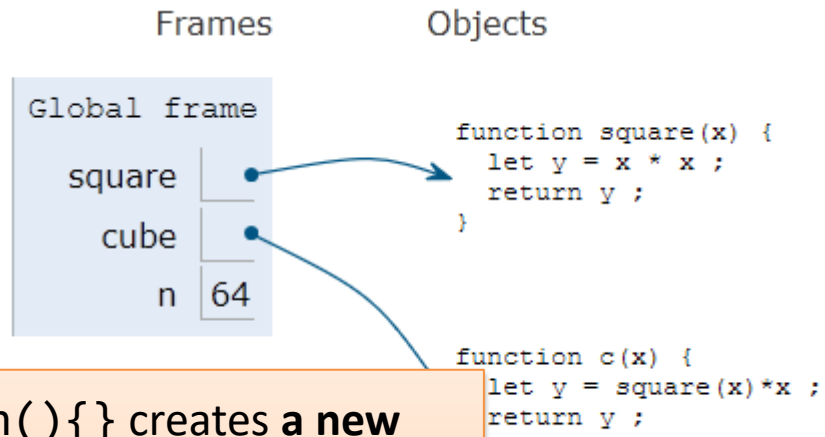
```
const fn = function do(params) {
  /* do something */
}
```

Function expression: indistinguishable

```
function square(x) {
  let y = x * x ;
  return y ;
}

let cube = function c(x) {
  let y = square(x)*x ;
  return y ;
}

let n = cube(4) ;
```



The *expression* `function(){}` creates **a new object of type 'function'** and returns the result.

Any variable may "refer" to the function and call it. You can also store that reference into an array, an object property, pass it as a parameter to a function, redefine it, …

method

callback

Declaring functions: 3 ways

1) Classic

```
function do(params) {
  /* do something */
}
```

2a) Function expression

```
const fn = function(params) {
  /* do something */
}
```

3) Arrow function

```
const fn = (params) => {
  /* do something */
}
```

2b) Named function expression

```
const fn = function do(params) {
  /* do something */
}
```

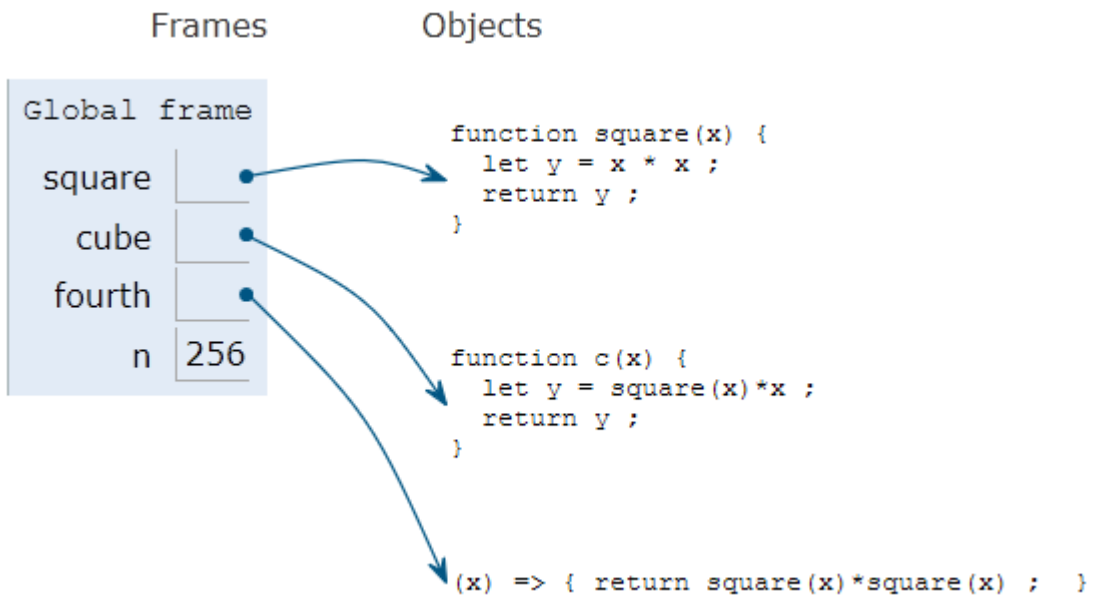
Arrow Function: just a shortcut

```
function square(x) {
  let y = x * x ;
  return y ;
}

let cube = function c(x) {
  let y = square(x)*x ;
  return y ;
}

let fourth = (x) => { return
square(x)*square(x) ;  }

let n = fourth(4) ;
```



Parameters in arrow functions

```
const fun = () => {  /* do something */ }          // no params

const fun = param => {  /* do something */ }       // 1 param

const fun = (param) => {  /* do something */ }     // 1 param

const fun = (par1, par2) => {  /* smtg */ } // 2 params

const fun = (par1 = 1, par2 = 'abc') => {  /* smtg */ }   // default values
```

Return value

- Default: `undefined`
- Use `return` to return a value
- Only one value can be returned
- However, objects (or arrays) can be returned

```
const fun = () => {  return ['hello', 5] ; }
const [ str, num ] = fun() ;
console.log(str) ;
```

- Arrow functions have implicit return if there is only one value

```
let fourth = (x) => { return square(x)*square(x) ;  }
let fourth = x => square(x)*square(x) ;
```

Nested functions

- Function can be nested, i.e., defined within another function

```
function hypotenuse(a, b) {
    const square = x => x*x ;
    return Math.sqrt(square(a) + square(b));
}
```

=> Preferred in nested functions

```
function hypotenuse(a, b) {
    function square(x) { return x*x; }
    return Math.sqrt(square(a) + square(b));
}
```

- The inner function is *scoped within* the external function and cannot be called outside
- The inner function might *access variables declared* in the *outside* function

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Chapter 9.4 Dates and Times

Mozilla Developer Network
Web technology for developers » JavaScript »
JavaScript reference »
Standard built-in objects » Date

Day.js
https://day.js.org/en/

JavaScript – The language of the Web

DATES

Date object

- Store a time instant with *millisecond* precision, counted from Jan 1, 1970 UTC (Unix Epoch)
- Careful with time zones
  - Most methods work in local time (not UTC) the computer is set to

```
let now = new Date();
```

```
let newYearMorning = new Date(
2021, // Year 2021
0, // January (from 0)
1, // 1st
18, 15, 10, 743);
// 18:15:10.743, local time
```

UTC vs Local time zone are confusing.

```
> new Date('2020-03-18')
2020-03-18T00:00:00.000Z
> new Date('18 March 2020')
2020-03-17T23:00:00.000Z
```

😱

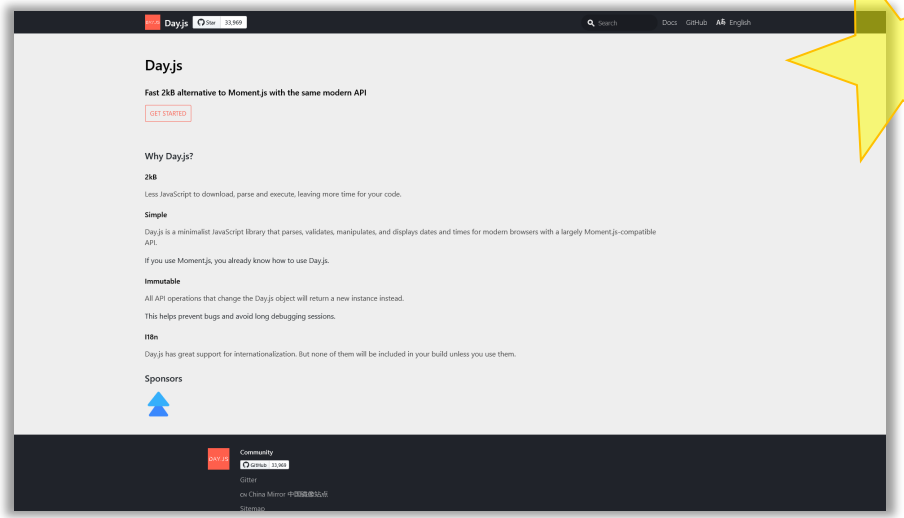
Formatting is locale-dependent

😱 😱

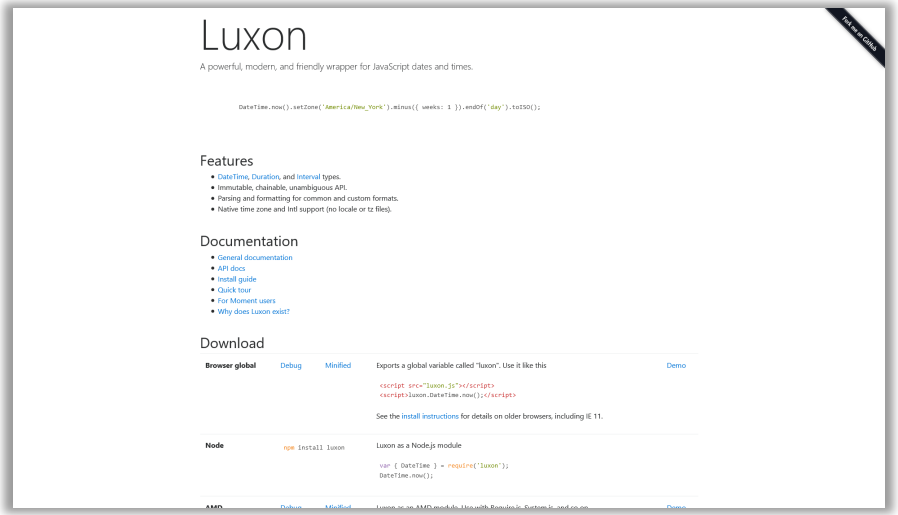
Comparisons are difficult (no way to specify which fields you want, must set them to zero explicitly)

😱 😱 😱

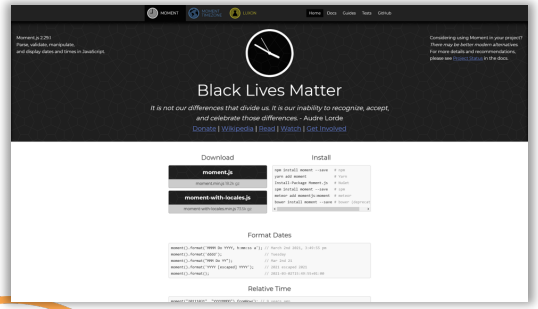
Serious JS date/time handling libraries



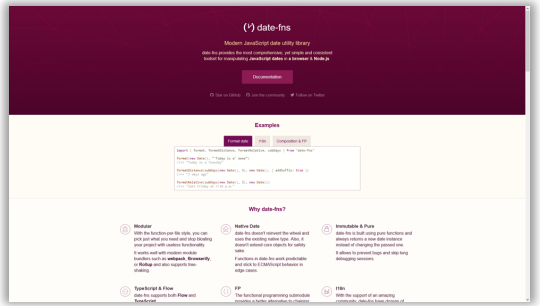
https://day.js.org/



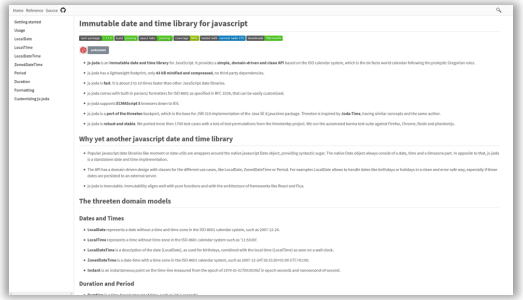
https://moment.github.io/luxon/



https://momentjs.com/



https://date-fns.org/



https://js-joda.github.io/js-joda/

Day.js Library

DAY.JS https://day.js.org/

- Goals
  - Compatible with moment.js
    - But very small (2kB)
  - Works in nodejs and in the browser
  - All objects are *immutable*
    - All API functions that modify a date, will always return a new object instance
  - Localization
  - Plugin system for extending functionality

Basic operations with Day.js

Creating date objects – dayjs() constructor

```
let now = dayjs()  // today
let date1 = dayjs('2019-12-27T16:00');
        // from ISO 8601 format
let date2 = dayjs('20191227');
        // from 8-digit format
let date3 = dayjs(new Date(2019, 11, 27));
        // from JS Date object
let date5 = dayjs.unix(1530471537);
    // from Unix timestamp

By default, Day.js parses in local time
```

https://day.js.org/docs/en/parse/parse

Displaying date objects – format()

```
console.log(now.format());
        2021-03-02T16:38:38+01:00

console.log(now.format('YYYY-MM [on the] DD'));
        2021-03 on the 02

console.log(now.toString());
        Tue, 02 Mar 2021 15:43:46 GMT

By default, Day.js displays in local time
```

Get/Set date/time components

```
# obj.unit() -> get
# obj.unit(new_val) -> set

let now2 = now.date(15);
let now2 = now.set('date', 15);
        2021-03-15T16:50:26+01:00

let now3 = now.minute(45);
let now3 = now.set('minute',45);
        2021-03-02T16:45:26+01:00

let today_day = now.day();
let today_day = now.get('day');
        2
```

Unit	Shorthand	Description
`date`	`D`	Date of Month
`day`	`d`	Day of Week (Sunday as 0, Saturday as 6)
`month`	`M`	Month (January as 0, December as 11)
`year`	`y`	Year
`hour`	`h`	Hour
`minute`	`m`	Minute
`second`	`s`	Second
`millisecond`	`ms`	Millisecond

https://day.js.org/docs/en/get-set/get-set

Date Manipulation and Comparison

```
let wow = dayjs('2019-01-25').add(1, 'day').subtract(1, 'year').year(2009).toString() ;
// "Sun, 25 Jan 2009 23:00:00 GMT"
```

- Methods to "modify" a date (and return a modified one)
- `.add` / `.subtract`
- `.startOf` / `.endOf`
- `d1.diff(d2, 'unit')`
- Specify the unit to be added/subtracted/rounded
- Can be easily *chained*

- Day.js objects can be compared
- `.isBefore` / `.isSame` / `.isAfter`
- `.isBetween`
- `.isLeapYear` / `.daysInMonth`

Day.js Plugins

- To keep install size minimal, several functions are only available in *plugins*
- Plugins must be
  - Loaded
  - Registered into the libraries
- Then, functions may be freely used

```
const isLeapYear =
   require('dayjs/plugin/isLeapYear’) ;
        // load plugin

dayjs.extend(isLeapYear) ;
        // register plugin

console.log(now.isLeapYear()) ;
        // use function
```

Advanced Day.js Topics

- Localization / Internationalization
  - Language-aware and locale-aware parsing and formatting
  - Various formatting patterns for different locales/languages
- Durations
  - Measuring time intervals (the difference between two time instants)
  - Interval arithmetic
- Time Zones
  - Conversion between time zones

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