

<WA1/>
<AW1/>
2024

JavaScript (basics)

“The” language of the Web

Fulvio Corno

Luigi De Russis

JavaScript Cheat Sheet
Programming Language of Web

JS **JS**

n Number()
PROPERTIES
n.POSITIVE_INFINITY +∞ equivalent
n.NEGATIVE_INFINITY -∞ equivalent
n.MAX_VALUE largest positive value
n.MIN_VALUE smallest positive value
n.EPSILON diff between 1 & smallest>1
n.NaN not-a-number value
METHODS
s.toExponential(**dec**) exp. notation
s.toFixed(**dec**) fixed-point notation
s.toPrecision(**n**) change precision
b.isFinite(**n**) check if number is finite
b.isInteger(**n**) check if number is int.
b.isNaN(**n**) check if number is NaN
n.parseInt(**s**, **radix**) string to integer
n.parseFloat(**s**, **radix**) string to float

r Regexp()
PROPERTIES
n.lastIndex index to start global regexp
s.flags active flags of current regexp
b.global flag g (search all matches)
b.ignoreCase flag i (match lower/upper)
b.multiline flag m (match multiple lines)
b.sticky flag y (search from lastIndex)
b.unicode flag u (enable unicode feat.)
s.source current regexp (w/o slashes)
METHODS
a.exec(**str**) exec search for a match
b.test(**str**) check if regexp match w/str

CLASSES
\. any character
\d digit [0-9]
\D no digit [^0-9]
\w any alphanumeric char [A-Za-z0-9_]
\W no alphanumeric char [^A-Za-z0-9_]
\s any space char (space, tab, enter...)
\S no space char (space, tab, enter...)
\xN char with code **N**
\uN char with unicode **N**
\0 NUL char

CHARACTER SETS OR ALTERNATION
[abc] match any character set
[^abc] match any char. set not enclosed
a|b match a or b

BOUNDARIES
^ begin of input
\$ end of input
\b zero-width word boundary
\B zero-width non-word boundary

GROUPING
(x) capture group
(?:x) no capture group
n reference to group **n** captured

QUANTIFIERS
x* preceding **x** 0 or more times {0,}
x+ preceding **x** 1 or more times {1,}
x? preceding **x** 0 or 1 times {0,1}
x{n} **n** occurrences of **x**
x{n,} at least **n** occurrences of **x**
x{n,m} between **n** & **m** occurrences of **x**

ASSERTIONS
x(?:y) **x** (only if **x** is followed by **y**)
x(?:!y) **x** (only if **x** is not followed by **y**)

s String()
PROPERTIES
n.length string size
METHODS
s.charAt(**index**) char at position
n.charCodeAt(**index**) unicode at pos.
s.fromCharCode(**n1**, **n2**,...) code to char
s.concat(**str1**, **str2**,...) combine text
b.startsWith(**str**, **size**) check beginning
b.endsWith(**str**, **size**) check ending
b.includes(**str**, **from**) include substring?
n.indexOf(**str**, **from**) find substr index
n.lastIndexOf(**str**, **from**) find from end
n.search(**regex**) search & return index
n.localeCompare(**str**, **locale**, **options**)
a.match(**regex**) matches against string
s.repeat(**n**) repeat string **n** times
s.replace(**str|regex**, **newstr|func**)
s.slice(**ini**, **end**) str between ini/end
s.substr(**ini**, **len**) substr of len length
s.substring(**ini**, **end**) substr fragment
a.split(**sep|regex**, **limit**) divide string
s.toLowerCase() string to lowercase
s.toUpperCase() string to uppercase
s.trim() remove space from begin/end
e.raw() template strings with \${vars}

d Date()
METHODS
n.UTC(**y**, **m**, **d**, **h**, **i**, **s**, **ms**) timestamp
n.now() timestamp of current time
n.parse(**str**) convert str to timestamp
n.setTime(**ts**) set UNIX timestamp
n.getTime() return UNIX timestamp
UNIT GETTERS (ALSO .getUTC() methods)
n.getFullYear(**y**, **m**, **d**) set year (yyyy)
n.setMonth(**m**, **d**) set month (0-11)
n.setDate(**d**) set day (1-31)
n.setHours(**h**, **m**, **s**, **ms**) set hour (0-23)
n.setMinutes(**m**, **s**, **ms**) set min (0-59)
n.setSeconds(**s**, **ms**) set sec (0-59)
n.setMilliseconds(**ms**) set ms (0-999)
UNIT GETTERS (ALSO .getUTC() methods)
n.getDate() return day (1-31)
n.getDay() return day of week (0-6)
n.getMonth() return month (0-11)
n.getFullYear() return year (yyyy)
n.getHours() return hour (0-23)
n.getMinutes() return minutes (0-59)
n.getSeconds() return seconds (0-59)
n.getMilliseconds() return ms (0-999)

LOCALE & TIMEZONE METHODS
n.getTimezoneOffset() offset in mins
s.toLocaleDateString(**locale**, **options**)
s.toLocaleTimeString(**locale**, **options**)
s.toLocaleString(**locale**, **options**)
s.toUTCString() return UTC date
s.toDate() return American date
s.toISOString() return ISO8601 date
s.toJSON() return date ready for JSON

a Array()
PROPERTIES
n.length number of elements
METHODS
b.isArray(**obj**) check if obj is array
b.includes(**obj**, **from**) include element?
n.indexOf(**obj**, **from**) find elem. index
n.lastIndexOf(**obj**, **from**) find from end
s.join(**sep**) join elements w/separator
a.slice(**ini**, **end**) return array portion
a.concat(**obj1**, **obj2**,...) return joined array
MODIFY SOURCE ARRAY METHODS
a.copyWithin(**pos**, **ini**, **end**) copy elems
a.fill(**obj**, **ini**, **end**) fill array with obj
a.reverse() reverse array & return it
a.sort(**cf(a,b)**) sort array (unicode sort)
a.splice(**ini**, **del**, **o1**, **o2**,...) del&add elem
ITERATION METHODS
a.entries() iterate key/value pair array
a.keys() iterate only keys array
a.values() iterate only values array
CALLBACK FOR EACH METHODS
b.every(**cb(e,i,a)**, **arg**) test until false
b.some(**cb(e,i,a)**, **arg**) test until true
a.map(**cb(e,i,a)**, **arg**) make array
a.filter(**cb(e,i,a)**, **arg**) make array w/true
a.find(**cb(e,i,a)**, **arg**) return elem w/true
a.findIndex(**cb(e,i,a)**, **arg**) return index
forEach(**cb(e,i,a)**, **arg**) exec for each
a.reduce(**cb(p,e,i,a)**, **arg**) accumulative
a.reduceRight(**cb(p,e,i,a)**, **arg**) from end
ADD/REMOVE METHODS
a.pop() remove & return last element
a.push(**o1**, **o2**,...) add element & return length
a.shift() remove & return first element
a.unshift(**o1**, **o2**,...) add element & return len

b Boolean()
no own properties or methods

f Function()
PROPERTIES
n.length return number of arguments
s.name return name of function
o.prototype prototype object
METHODS
o.call(**newthis**, **arg1**, **arg2**,...) change **this**
o.apply(**newthis**, **arg1**) with args array
o.bind(**newthis**, **arg1**, **arg2**,...) bound func

n number
NaN (not-a-number)
s string
b boolean (true/false)
a array
d date
r regular expression
f function
o object
u undefined
only available on ECMAScript 6
o static (ex: Math.random())
n non-static (ex: new Date().getDate())
a argument required
a argument optional

CodeMio

Number()
PROPERTIES
 ○ POSITIVE_INFINITY +∞ equivalent
 ○ NEGATIVE_INFINITY -∞ equivalent
 ○ MAX_VALUE largest positive value
 ○ MIN_VALUE smallest positive value
 ○ EPSILON diff between 1 & smallest >1
 ○ NaN not-a-number value
METHODS
 ○ toExponential(dec) exp. notation
 ○ toFixed(dec) fixed-point notation
 ○ toPrecision(p) change precision
 ○ isFinite(n) check if number is finite
 ○ isInteger(n) check if number is int.
 ○ isNaN(n) check if number is NaN
 ○ parseInt(s, radix) string to integer
 ○ parseFloat(s, radix) string to float

RegExp()
PROPERTIES
 ○ lastIndex index to start global regexp
 ○ flags active flags of current regexp
 ○ global flag g (search all matches)
 ○ ignoreCase flag i (match lower/upper)
 ○ multiline flag m (match multiple lines)
 ○ sticky flag y (search from lastIndex)
 ○ unicode flag u (enable unicode feat.)
 ○ source current regexp (w/o slashes)
METHODS
 ○ exec(str) exec search for a match
 ○ test(str) check if regexp match w/str
CLASSES
 ○ any character \t tabulator
 ○ \d digit [0-9] \r carriage return
 ○ \D no digit [^0-9] \n line feed
 ○ \w any alphanumeric char [A-Za-z0-9_]
 ○ \W no alphanumeric char [^A-Za-z0-9_]
 ○ \s any space char (space, tab, enter...)
 ○ \S no space char (space, tab, enter...)
 ○ \xN char with code N [NB] backspace
 ○ \uN char with unicode N \0 NUL char
CHARACTER SETS OR ALTERNATION
 ○ [abc] match any character set
 ○ [^abc] match any char. set not enclosed
 ○ a|b match a or b
BOUNDARIES
 ○ ^ begin of input \$ end of input
 ○ \b zero-width word boundary
 ○ \B zero-width non-word boundary
GROUPING
 ○ (x) capture group (?x) no capture group
 ○ \n reference to group n captured
QUANTIFIERS
 ○ * preceding x 0 or more times {0,}
 ○ + preceding x 1 or more times {1,}
 ○ ? preceding x 0 or 1 times {0,1}
 ○ x{n} n occurrences of x
 ○ x{n,} at least n occurrences of x
 ○ x{n,m} between n & m occurrences of x
ASSERTIONS
 ○ x(?:y) x (only if x is followed by y)
 ○ x(?!y) x (only if x is not followed by y)

String()
PROPERTIES
 ○ length string size
METHODS
 ○ charAt(index) char at position [i]
 ○ charCodeAt(index) unicode at pos.
 ○ fromCharCode(n1, n2...) code to char
 ○ concat(str1, str2...) combine text +
 ○ startsWith(str, size) check beginning
 ○ endsWith(str, size) check ending
 ○ includes(str, from) include substring?
 ○ indexOf(str, from) find substr index
 ○ lastIndexOf(str, from) find from end
 ○ search(regex) search & return index
 ○ localeCompare(str, locale, options)
 ○ match(regex) matches against string
 ○ repeat(n) repeat string n times
 ○ replace(str|regex, newstr|func)
 ○ slice(ini, end) str between ini/end
 ○ substr(ini, len) substr of len length
 ○ substring(ini, end) substr fragment
 ○ split(sep|regex, limit) divide string
 ○ toLowerCase() string to lowercase
 ○ toUpperCase() string to uppercase
 ○ trim() remove space from begin/end
 ○ raw() template strings with \${vars}

Date()
METHODS
 ○ UTC(y, m, d, h, i, s, ms) timestamp
 ○ now() timestamp of current time
 ○ parse(str) convert str to timestamp
 ○ setTime(ts) set UNIX timestamp
 ○ getTime() return UNIX timestamp
UNIT SETTERS (ALSO setUTC() methods)
 ○ setFullYear(y, m, d) set year (yyyy)
 ○ setMonth(m, d) set month (0-11)
 ○ setDate(d) set day (1-31)
 ○ setHours(h, m, s, ms) set hour (0-23)
 ○ setMinutes(m, s, ms) set min (0-59)
 ○ setSeconds(s, ms) set sec (0-59)
 ○ setMilliseconds(ms) set ms (0-999)
UNIT GETTERS (ALSO getUTC() methods)
 ○ getDate() return day (1-31)
 ○ getDay() return day of week (0-6)
 ○ getMonth() return month (0-11)
 ○ getFullYear() return year (yyyy)
 ○ getHours() return hour (0-23)
 ○ getMinutes() return minutes (0-59)
 ○ getSeconds() return seconds (0-59)
 ○ getMilliseconds() return ms (0-999)

Locale & Timezone Methods
 ○ getTimezoneOffset() offset in mins
 ○ toLocaleDateString(locale, options)
 ○ toLocaleTimeString(locale, options)
 ○ toLocaleString(locale, options)
 ○ toUTCString() return UTC date
 ○ toString() return American date
 ○ toTimeString() return American time
 ○ toISOString() return ISO8601 date
 ○ toJSON() return date ready for JSON

Array()
PROPERTIES
 ○ length number of elements
METHODS
 ○ isArray(obj) check if obj is array
 ○ includes(obj, from) include element?
 ○ indexOf(obj, from) find elem. index
 ○ lastIndexOf(obj, from) find from end
 ○ join(sep) join elements w/separator
 ○ slice(ini, end) return array portion
 ○ concat(obj1, obj2...) return joined array
MODIFY SOURCE ARRAY METHODS
 ○ copyWithin(pos, ini, end) copy elems
 ○ fill(fill, ini, end) fill array with obj
 ○ reverse() reverse array & return it
 ○ sort(cmp(a,b)) sort array (unicode sort)
 ○ splice(ini, del, o1, o2...) del&add elem
ITERATION METHODS
 ○ entries() iterate key/value pair array
 ○ keys() iterate only keys array
 ○ values() iterate only values array
CALLBACK FOR EACH METHODS
 ○ every(cb(e,i,a), arg) test until false
 ○ some(cb(e,i,a), arg) test until true
 ○ map(cb(e,i,a), arg) make array
 ○ filter(cb(e,i,a), arg) make array w/true
 ○ find(cb(e,i,a), arg) return elem w/true
 ○ findIndex(cb(e,i,a), arg) return index
 ○ forEach(cb(e,i,a), arg) exec for each
 ○ reduce(cb(p,e,i,a), arg) accumulative
 ○ reduceRight(cb(p,e,i,a), arg) from end

ADD/REMOVE METHODS
 ○ pop() remove & return last element
 ○ push(o1, o2...) add element & return length
 ○ shift() remove & return first element
 ○ unshift(o1, o2...) add element & return len

Boolean()
 no own properties or methods

Function()
PROPERTIES
 ○ length return number of arguments
 ○ name return name of function
 ○ prototype prototype object
METHODS
 ○ call(newthis, arg1, arg2...) change this
 ○ apply(newthis, arg1) with args array
 ○ bind(newthis, arg1, arg2...) bound func
number
 ○ NaN (not-a-number) **date**
 ○ string **regular expression**
 ○ boolean (true/false) **object**
 ○ array **undefined**
 only available on ECMAScript 6
 ○ static (ex: Math.random())
 ○ non-static (ex: new Date(), getDate())
 argument required
 argument optional

Math
PROPERTIES
 ○ E Euler's constant
 ○ LN2 natural logarithm of 2
 ○ LN10 natural logarithm of 10
 ○ LOG2E base 2 logarithm of E
 ○ LOG10E base 10 logarithm of E
 ○ PI ratio circumference/diameter
 ○ SQRT1_2 square root of 1/2
 ○ SQRT2 square root of 2
METHODS
 ○ abs(x) absolute value
 ○ cbrt(x) cube root
 ○ clz32(x) return leading zero bits (32)
 ○ exp(x) return e^x
 ○ expm1(x) return e^x-1
 ○ hypot(x1, x2...) length of hypotenuse
 ○ imul(a, b) signed multiply
 ○ log(x) natural logarithm (base e)
 ○ log1p(x) natural logarithm (1+x)
 ○ log10(x) base 10 logarithm
 ○ log2(x) base 2 logarithm
 ○ max(x1, x2...) return max number
 ○ min(x1, x2...) return min number
 ○ pow(base, exp) return base^exp
 ○ random() float random number [0,1)
 ○ sign(x) return sign of number
 ○ sqrt(x) square root of number

ROUND METHODS
 ○ ceil(x) superior round (smallest)
 ○ floor(x) inferior round (largest)
 ○ fround(x) nearest single precision
 ○ round(x) round (nearest integer)
 ○ trunc(x) remove fractional digits
TRIGONOMETRIC METHODS
 ○ acos(x) arccosine
 ○ acosh(x) hyperbolic arccosine
 ○ asin(x) arcsine
 ○ asinh(x) hyperbolic arcsine
 ○ atan(x) arctangent
 ○ atan2(x, y) arctangent of quotient x/y
 ○ atanh(x) hyperbolic arctangent
 ○ cos(x) cosine
 ○ cosh(x) hyperbolic cosine
 ○ sin(x) sine
 ○ sinh(x) hyperbolic sine
 ○ tan(x) tangent
 ○ tanh(x) hyperbolic tangent

JSON
METHODS
 ○ parse(str, tf(k,v)) parse string to object
 ○ stringify(obj, repl[w], sp) convert to str

Error()
PROPERTIES
 ○ name return name of error
 ○ message return description of error

Object()
PROPERTIES
 ○ constructor return ref. to object func.
METHODS
 ○ assign(dst, src1, src2...) copy values
 ○ create(proto, prop) create obj w/prop
 ○ defineProperties(obj, prop)
 ○ defineProperty(obj, prop, desc)
 ○ freeze(obj) avoid properties changes
 ○ getOwnPropertyDescriptor(obj, prop)
 ○ getOwnPropertyNames(obj)
 ○ getOwnPropertySymbols(obj)
 ○ getPrototypeOf(obj) return prototype
 ○ is(val1, val2) check if are same value
 ○ isExtensible(obj) check if can add prop
 ○ isFrozen(obj) check if obj is frozen
 ○ isSealed(obj) check if obj is sealed
 ○ keys(obj) return only keys of object
 ○ preventExtensions(obj) avoid extend
 ○ seal(obj) prop are non-configurable
 ○ setPrototypeOf(obj, prot) change prot
INSTANCE METHODS
 ○ hasOwnProperty(prop) check if exist
 ○ isPrototypeOf(obj) test in another obj
 ○ propertyIsEnumerable(prop)
 ○ toString() return equivalent string
 ○ toLocaleString() return locale version
 ○ valueOf() return primitive value

Promise()
METHODS
 ○ all(obj) return promise
 ○ catch(onRejected(s)) = .then(undef, s)
 ○ then(onFulfilled(v), onRejected(s))
 ○ race(obj) return greedy promise (res/req)
 ○ resolve(obj) return resolved promise
 ○ reject(reason) return rejected promise

Proxy()
METHODS
 ○ apply(obj, arg, arglist) trap function call
 ○ construct(obj, arglist) trap new oper
 ○ defineProperty(obj, prop, desc)
 ○ deleteProperty(obj, prop) trap delete
 ○ enumerate(obj) trap for...in
 ○ get(obj, prop, rec) trap get property
 ○ getOwnPropertyDescriptor(obj, prop)
 ○ getPrototypeOf(obj)
 ○ has(obj, prop) trap in operator
 ○ ownKeys(obj)
 ○ preventExtensions(obj)
 ○ set(obj, prop, value) trap set property
 ○ setPrototypeOf(obj, proto)

globals
METHODS
 ○ eval(str) evaluate javascript code
 ○ isFinite(obj) check if is a finite number
 ○ isNaN(obj) check if is not a number
 ○ parseInt(s, radix) string to integer
 ○ parseFloat(s, radix) string to float
 ○ encodeURIComponent(URI) = to %3D
 ○ decodeURIComponent(URI) %3D to =

Symbol()
PROPERTIES
 ○ iterator specifies default iterator
 ○ match specifies match of regexp
 ○ species specifies constructor function
METHODS
 ○ for(key) search existing symbols
 ○ keyFor(sym) return key from global reg
Generator()
METHODS
 ○ next(value) return obj w/(value,done)
 ○ return(value) return value & true done
 ○ throw(throw) throw an error
Others
 var declare variable
 let declare block scope local variable
 const declare constant (read-only)
 func(a=1) default parameter value
 func(...a) rest argument (spread operator)
 (a) => { ... } function equivalent (fat arrow)
 'string \${a}' template with variables
 0bn binary (2) number n to decimal
 0on octal (8) number n to decimal
 0xn hexadecimal (16) number n to decimal
 for (i in array) { ... } iterate array, i = index
 for (e of array) { ... } iterate array, e = value
 class B extends A { } class sugar syntax

Goal

- Learn JavaScript as a language
- Understand the specific semantics and programming patterns
 - We assume a programming knowledge in other languages
- Updated to ES6 (2015) language features
- Supported by server-side (Node.js) and client-side (browsers) run-time environments
 - More recent language additions also supported (through *transpiling*)

Outline

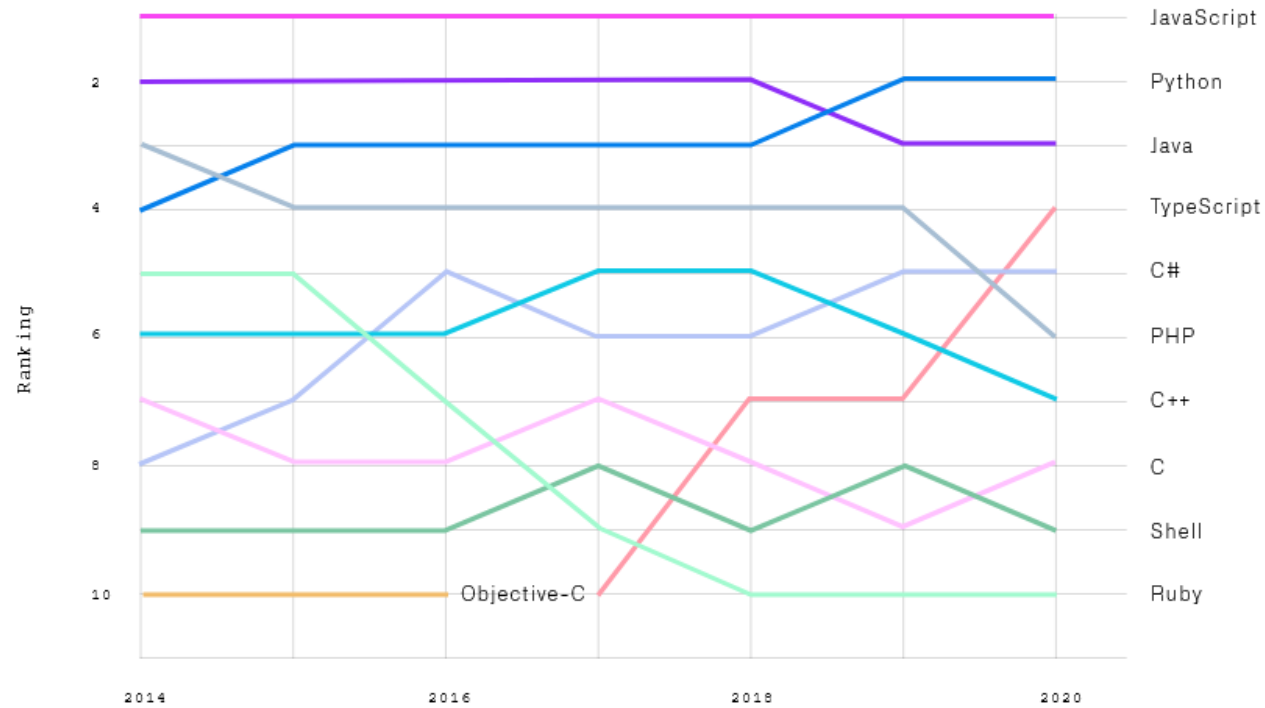
- What is JavaScript?
- History and versions
- Language structure
- Types, variables
- Expressions
- Control structures
- Arrays
- Strings

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)** Regexp, Try/Catch, Do-While, String methods
- ▶ **ES5 (December 2009)** Strict mode, JSON, .bind, Object mts, Array mts
- ▶ **ES5.1 (June 2011)** Editorial changes for ISO 16262:2011
- ▶ **ES6 (June 2015)** Classes, Modules, Arrow Fs, Generators, Const/Let, Destructuring, Template Literals, Promise, Proxy, Symbol, Reflect
- ▶ **ES7 (June 2016)** Exponentiation operator (**) and Array Includes
- ▶ **ES8 (June 2017)** Async Fs, Shared Memory & Atomics

Also: ES2015

Also: ES2016

Also: ES2017

10 yrs

Main target

ES9, ES10, ...

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)



Search...

TABLE OF CONTENTS

- Introduction
- 1 Scope
- 2 Conformance
- 3 Normative References
- 4 Overview
- 5 Notational Conventions
- 6 ECMAScript Data Types and Values
- 7 Abstract Operations
- 8 Executable Code and Execution Contexts
- 9 Ordinary and Exotic Objects Behaviours
- 10 ECMAScript Language: Source Code
- 11 ECMAScript Language: Lexical Grammar
- 12 ECMAScript Language: Expressions
- 13 ECMAScript Language: Statements and Declarations
- 14 ECMAScript Language: Functions and Classes
- 15 ECMAScript Language: Scripts and Modules
- 16 Error Handling and Language Extensions
- 17 ECMAScript Standard Built-in Objects
- 18 The Global Object
- 19 Fundamental Objects
- 20 Numbers and Dates
- 21 Text Processing
- 22 Indexed Collections
- 23 Keyed Collections
- 24 Structured Data
- 25 Control Abstraction Objects
- 26 Reflection
- 27 Memory Model
- A Grammar Summary
- B Additional ECMAScript Features for Web Browsers
- C The Strict Mode of ECMAScript
- D Corrections and Clarifications in ECMAScript 2015 wit...
- E Additions and Changes That Introduce Incompatibiliti...
- F Colophon
- G Bibliography
- H Copyright & Software License

ecma
INTERNATIONAL

ECMA-262, 10th edition, June 2019
ECMAScript® 2019 Language Specification

Contributing to this Specification

This specification is developed on GitHub with the help of the ECMAScript community. There are a number of ways to contribute to the development of this specification:

GitHub Repository: <https://github.com/tc39/ecma262>
Issues: [All Issues](#), [File a New Issue](#)
Pull Requests: [All Pull Requests](#), [Create a New Pull Request](#)
Test Suite: [Test262](#)

Editors:

- Brian Terlson (@bterlson)
- Bradley Farias (@bradleymeck)
- Jordan Harband (@ljharb)

Community:

- Mailing list: [es-discuss](#)
- IRC: [#tc39](#) on freenode

Refer to the [colophon](#) for more information on how this document is created.

Introduction

<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	?

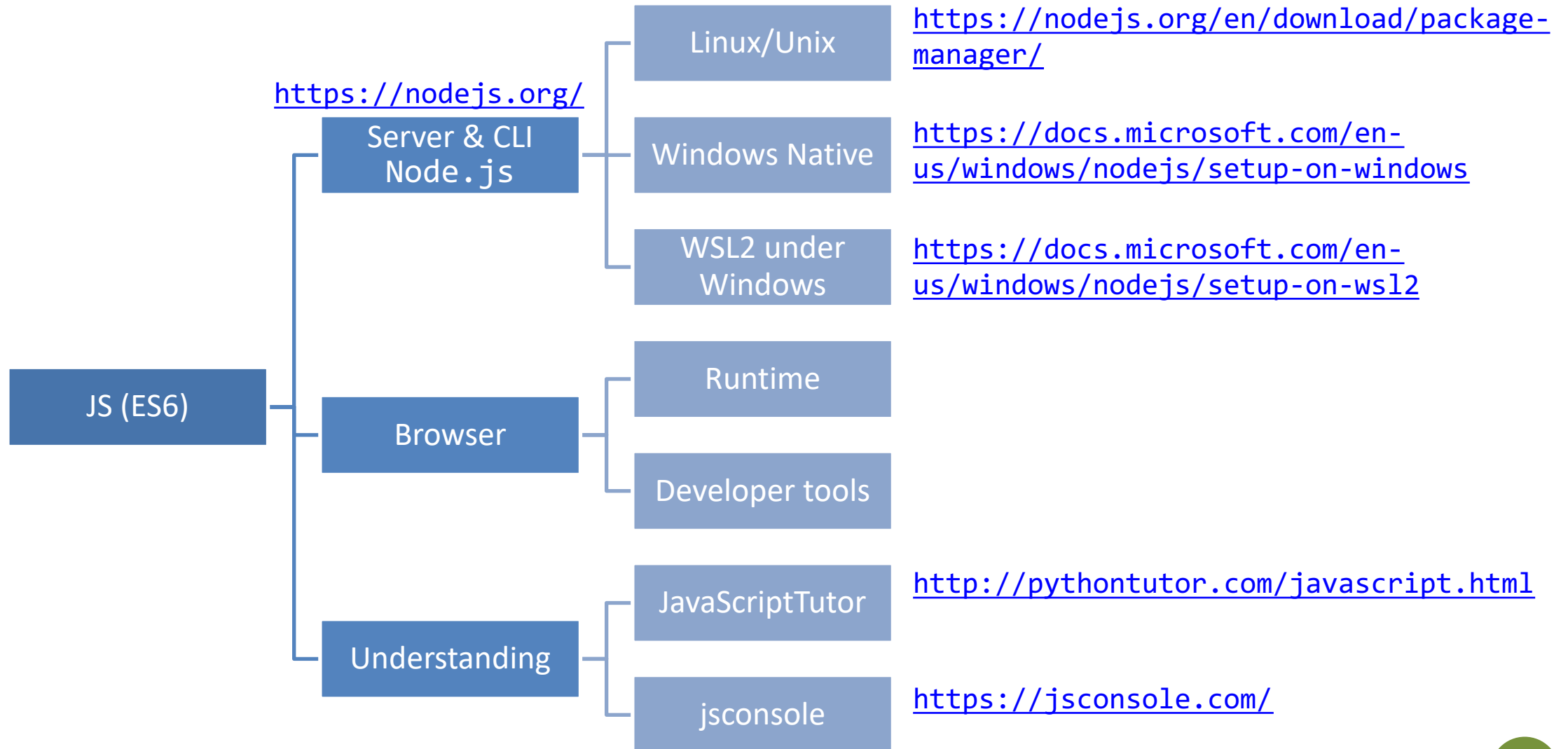
What are we missing?

- Full support
- Compatibility unknown
- ⚠️ Non-standard. Expect poor cross-browser support.
- * See implementation notes.
- .. No support
- ⚠️ Experimental. Expect behavior to change in the future.
- ⚠️ Deprecated. Not for use in new websites.

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

Write code in JavaScript ES6 (drag lower right corner to resize code editor)

```
1 let nome = "Fulvio" ;
2 let cognome = "Corno" ;
3
4 function hello(c, n) {
5   n = n || "sig."
6   const saluto = n + " " + c ;
7   return saluto ;
8 }
9
10 let s1 = hello(cognome, nome)
11 let s2 = hello(nome)
12
13 let nome2 = [...nome]
14 let cognome2 = [...cognome]
```

→ line that just executed

→ next line to execute

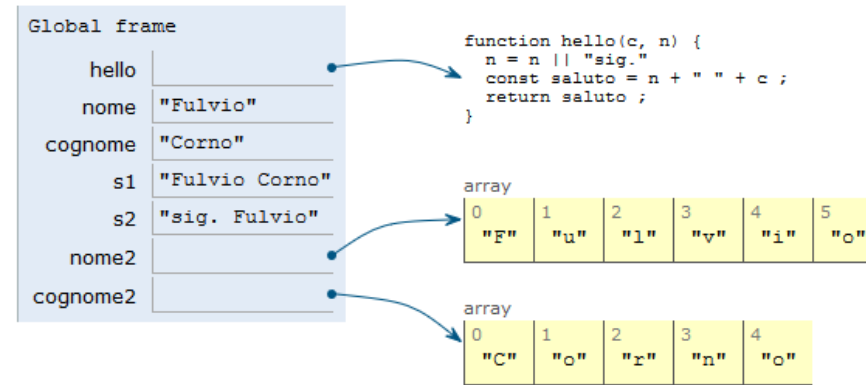


<< First < Prev Next > Last >>

Done running (16 steps)

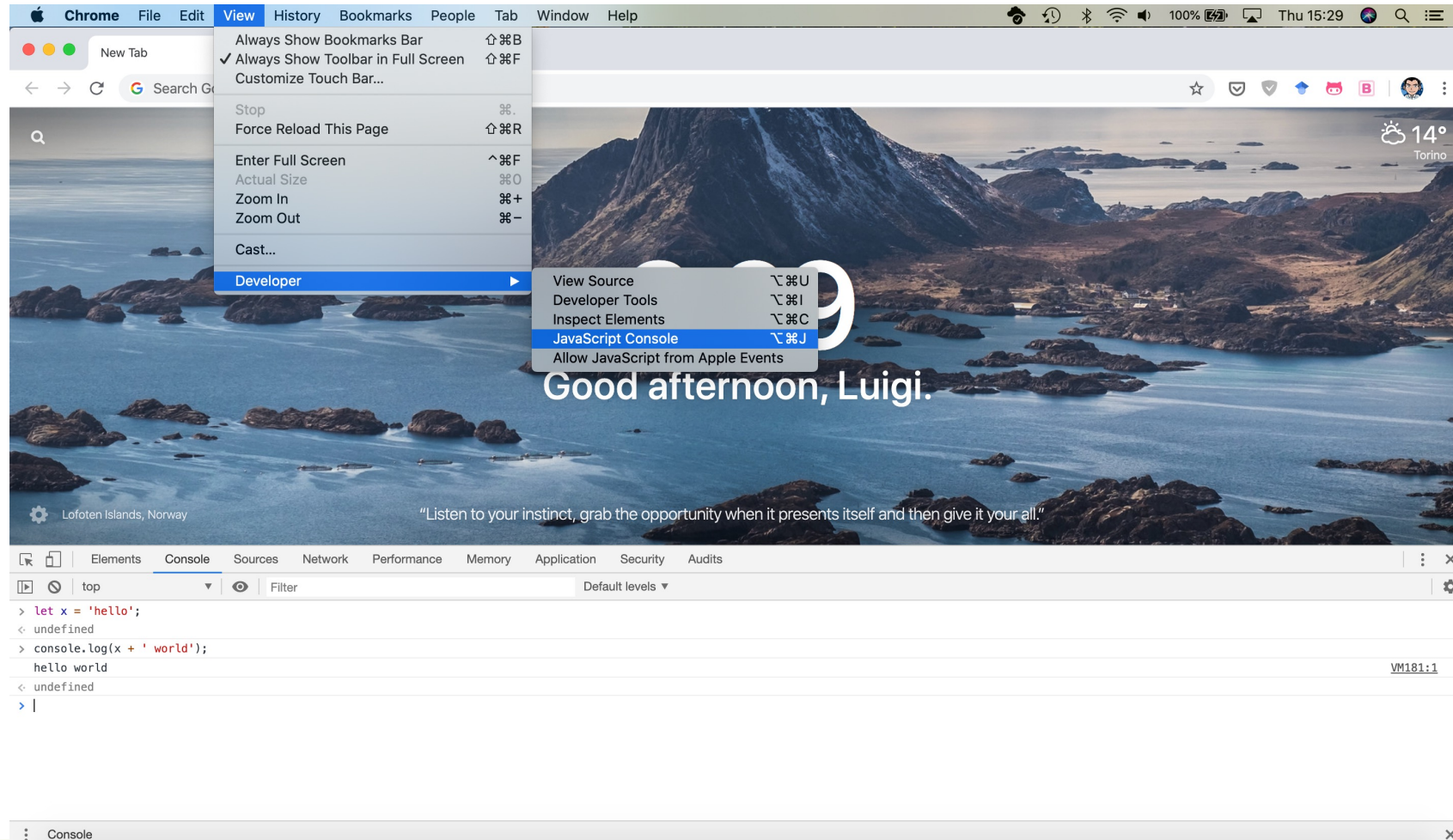
Frames

Objects



<http://pythontutor.com/javascript.html>

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 ööö = 'appalled'  
> ööö  
'appalled'
```

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

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

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)
 - ...



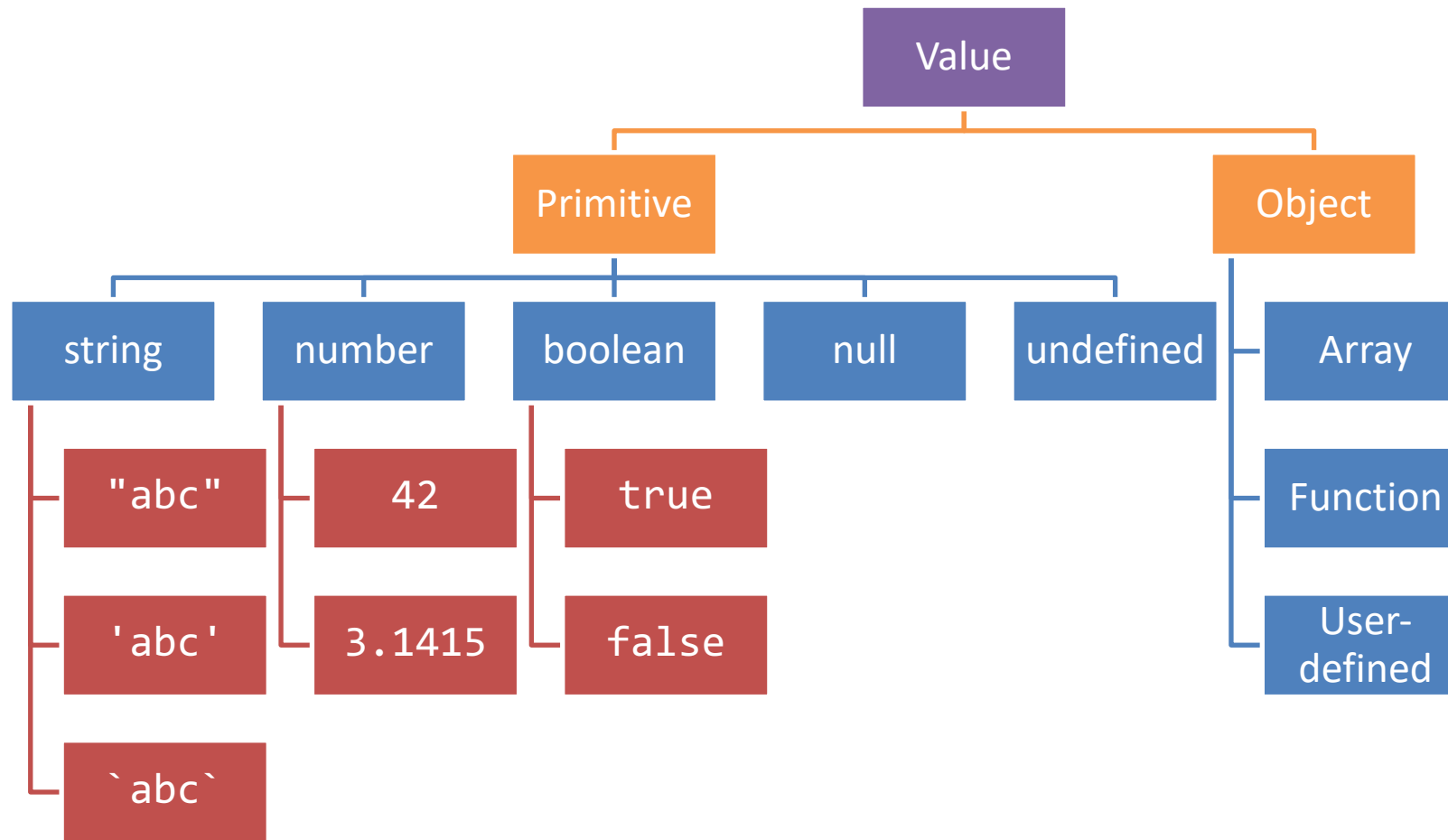
JavaScript: The Definitive Guide, 7th Edition
Chapter 2. Types, Values, and Variables

JavaScript – The language of the Web

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

- 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**

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

```
> 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	<i>Preferred</i>
const	No [§]	No	Enclosing block {...}	No	<i>Preferred</i>
var	Yes	Yes	Enclosing function, or global	Yes, to beginning of function or file	<i>Legacy, beware its quirks, try not to use</i>
None (implicit)	Yes	N/A	Global	Yes	<i>Forbidden in strict mode</i>

[§] 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.

Scope and Hoisting

```
"use strict" ;

function example(x) {
  let a = 1 ;
  console.log(a) ; // 1
  console.log(b) ; // ReferenceError: b is not defined
  console.log(c) ; // undefined

  if( x>1 ) {
    let b = a+1 ;
    var c = a*2 ;
  }

  console.log(a) ; // 1
  console.log(b) ; // ReferenceError: b is not defined
  console.log(c) ; // 2
}

example(2) ;
```

`var c ; // hoisted`



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

JavaScript – The language of the Web

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	<code>x = y</code>	<code>x = y</code>
Addition assignment	<code>x += y</code>	<code>x = x + y</code>
Subtraction assignment	<code>x -= y</code>	<code>x = x - y</code>
Multiplication assignment	<code>x *= y</code>	<code>x = x * y</code>
Division assignment	<code>x /= y</code>	<code>x = x / y</code>
Remainder assignment	<code>x %= y</code>	<code>x = x % y</code>
Exponentiation assignment 	<code>x **= y</code>	<code>x = x ** y</code>
Left shift assignment	<code>x <<= y</code>	<code>x = x << y</code>
Right shift assignment	<code>x >>= y</code>	<code>x = x >> y</code>
Unsigned right shift assignment	<code>x >>>= y</code>	<code>x = x >>> y</code>
Bitwise AND assignment	<code>x &= y</code>	<code>x = x & y</code>
Bitwise XOR assignment	<code>x ^= y</code>	<code>x = x ^ y</code>
Bitwise OR assignment	<code>x = y</code>	<code>x = x y</code>

Comparison operators



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

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 }
```

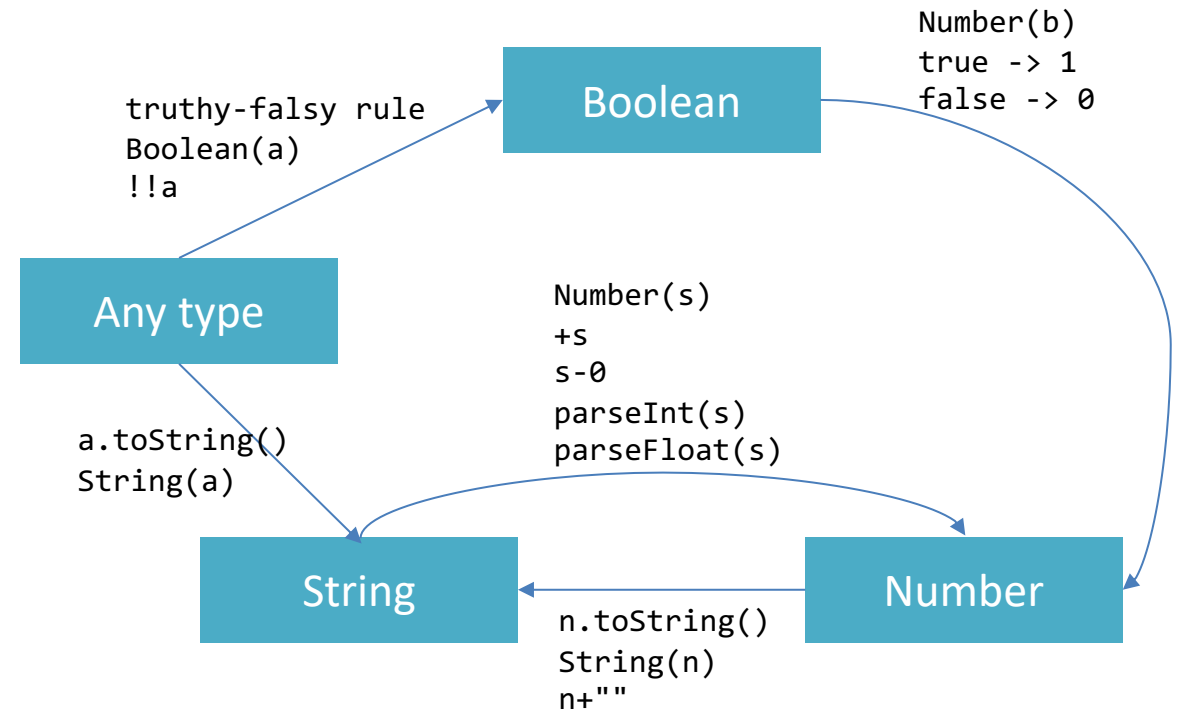
```
> b={x:1}
{ x: 1 }
```

```
> a===b
false
```

```
> a==b
false
```

Automatic Type Conversions

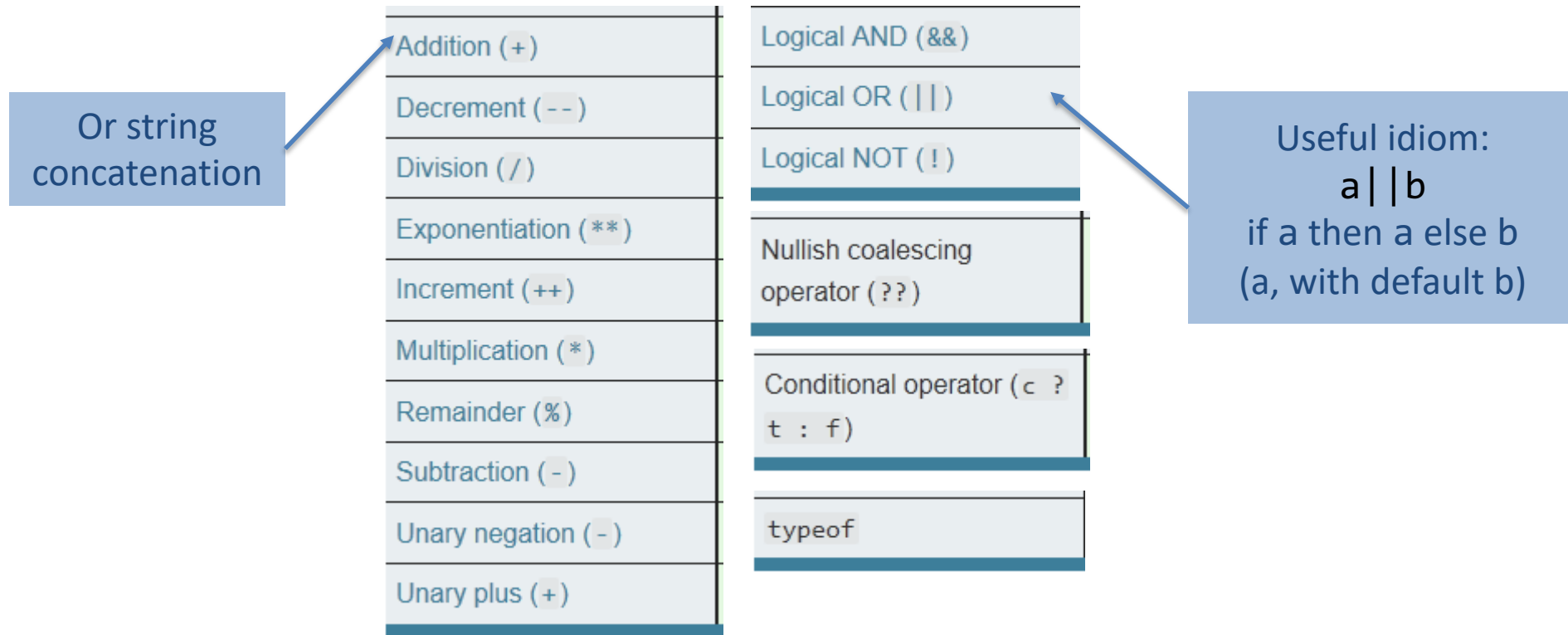
- JS tries to apply type conversions between primitive types, before applying operators
- Some language constructs may be used to “force” the desired conversions
- Using `==` applies conversions
- Using `===` prevents conversions



Logical operators

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

Common operators



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

JavaScript – The language of the Web

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;  
}
```

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

May also be a string

Loop statements

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

Usually declares loop variable

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

May use break; or continue;

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

Special 'for' statements

```
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()`
- They will be analyzed later

Exception handling

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

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

```
throw object ;
```

Exception 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

Mozilla Developer Network
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

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

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

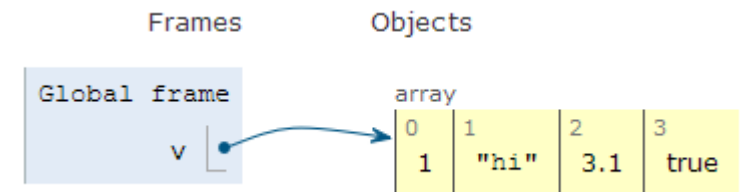
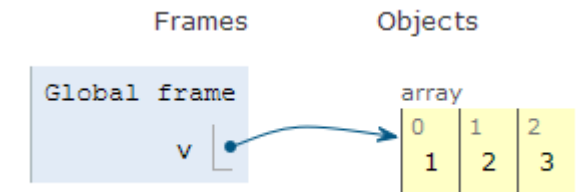
```
let v = [1, "hi", 3.1, true];
```

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

Do not access elements outside range

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

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



Adding elements

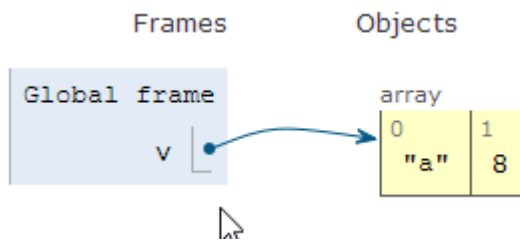
`.length` adjusts automatically

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

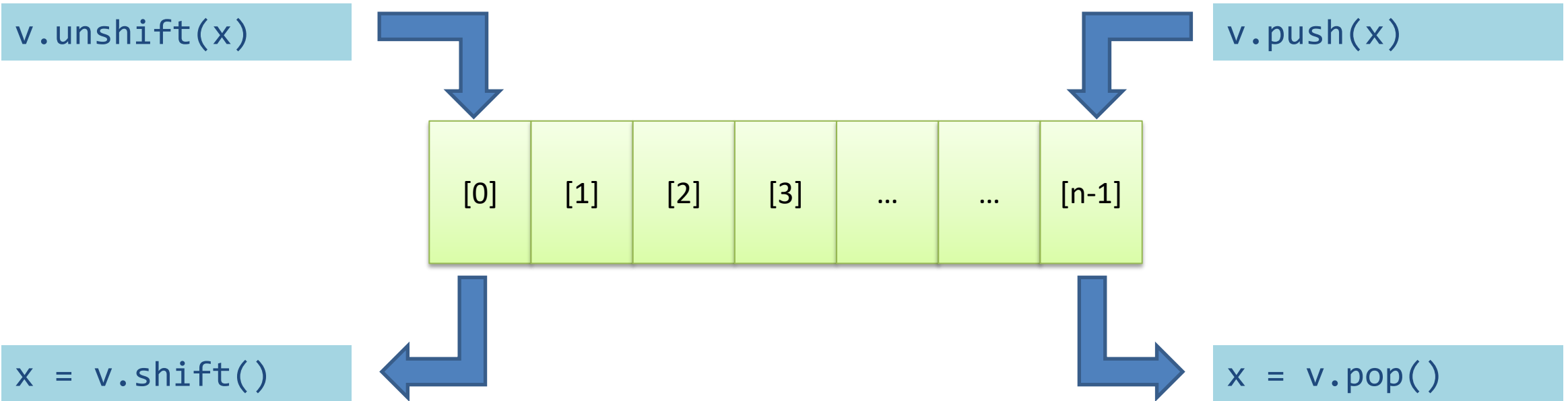
```
let v = [] ;  
v.push("a") ;  
v.push(8) ;  
v.length // 2
```

`.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 ;
```

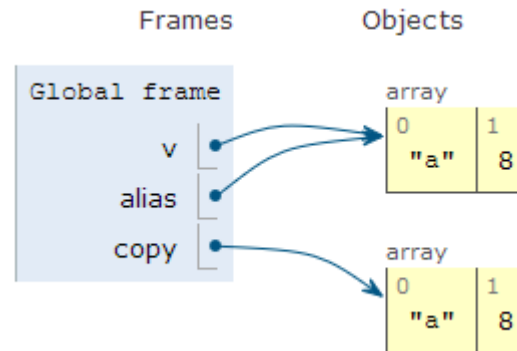
```
> console.log(v); ?  
[ 'a', 5 ]  
undefined  
> console.log(alias);  
[ 'a', 5 ]  
undefined
```

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 – later

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 iterable 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



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

Mozilla Developer Network
JavaScript Guide » Text Formatting

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

Unicode issues

- Strings are a sequence of 16-bit Unicode ‘code units’
 - Fine for all Unicode characters from 0000 to FFFF
 - Characters (‘graphemes’) from 010000 to 10FFFF are represented by *a pair of code units* (and they occupy 2 index positions)
 - Therefore, not all string methods work well with Unicode characters above FFFF (e.g., emojis, flags, ...)
- For more details: <https://dmitripavlutin.com/what-every-javascript-developer-should-know-about-unicode/>

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



License

- These slides are distributed under a Creative Commons license “**Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0)**”
- **You are free to:**
 - **Share** — copy and redistribute the material in any medium or format
 - **Adapt** — remix, transform, and build upon the material
 - The licensor cannot revoke these freedoms as long as you follow the license terms.
- **Under the following terms:**
 - **Attribution** — You must give [appropriate credit](#), provide a link to the license, and [indicate if changes were made](#). You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.
 - **NonCommercial** — You may not use the material for [commercial purposes](#).
 - **ShareAlike** — If you remix, transform, or build upon the material, you must distribute your contributions under the [same license](#) as the original.
 - **No additional restrictions** — You may not apply legal terms or [technological measures](#) that legally restrict others from doing anything the license permits.
- <https://creativecommons.org/licenses/by-nc-sa/4.0/>

