

# JavaScript

**JavaScript** (/ˈdʒɑːvəˌskript/),<sup>[10]</sup> often abbreviated as **JS**, is a programming language that conforms to the ECMAScript specification.<sup>[11]</sup> JavaScript is high-level, often just-in-time compiled and multi-paradigm. It has dynamic typing, prototype-based object-orientation and first-class functions.

Alongside HTML and CSS, JavaScript is one of the core technologies of the World Wide Web.<sup>[12]</sup> Over 97% of websites use it client-side for web page behavior,<sup>[13]</sup> often incorporating third-party libraries.<sup>[14]</sup> All major web browsers have a dedicated JavaScript engine to execute the code on the user's device.

As a multi-paradigm language, JavaScript supports event-driven, functional, and imperative programming styles. It has application programming interfaces (APIs) for working with text, dates, regular expressions, standard data structures, and the Document Object Model (DOM).

The ECMAScript standard does not include any input/output (I/O), such as networking, storage, or graphics facilities. In practice, the web browser or other runtime system provides JavaScript APIs for I/O.

JavaScript engines were originally used only in web browsers, but they are now core components of some servers and a variety of applications. The most popular runtime system for this usage is Node.js.

Although there are similarities between JavaScript and Java, including language name, syntax, and respective standard libraries, the two languages are distinct and differ greatly in design.

## JavaScript

<b>Paradigm</b>	event-driven, functional, imperative
<b>Designed by</b>	Brendan Eich of Netscape initially; others have also contributed to the ECMAScript standard
<b>First appeared</b>	December 4, 1995 <sup>[1]</sup>
<b>Stable release</b>	ECMAScript 2021 <sup>[2]</sup> <span><span></span></span> / June 2021
<b>Preview release</b>	ECMAScript 2022 <sup>[3]</sup> <span><span></span></span> / 22 July 2021
<b>Typing discipline</b>	Dynamic, weak, duck
<b>Filename extensions</b>	.js · .cjs · .mjs <sup>[4]</sup>
<b>Website</b>	<span>www.ecma-international.org/publications-and-standards/standards/ecma-262/</span> ( <span>https://www.ecma-international.org/publications-and-standards/standards/ecma-262/</span> )
<b>Major implementations</b>	
V8, JavaScriptCore, SpiderMonkey, Chakra	
<b>Influenced by</b>	
Java, <sup>[5][6]</sup> Scheme, <sup>[6]</sup> Self, <sup>[7]</sup> AWK, <sup>[8]</sup> HyperTalk <sup>[9]</sup>	

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# History

## Creation at Netscape

The [Mosaic web browser](#) was released in 1993. As the first browser with a [graphical user interface](#) accessible to non-technical people, it played a prominent role in the rapid growth of the nascent [World Wide Web](#).<sup>[15]</sup> The lead developers of Mosaic then founded the [Netscape corporation](#), which released a more polished browser, [Netscape Navigator](#), in 1994. Navigator quickly became the most used browser.<sup>[16][17]</sup>

During these formative years of the Web, [web pages](#) could only be static, lacking the capability for dynamic behavior after the page was loaded in the browser. There was a desire in the burgeoning web development scene to remove this limitation, so in 1995, Netscape decided to add a [scripting](#)

language to Navigator. They pursued two routes to achieve this: collaborating with Sun Microsystems to embed the Java programming language, while also hiring Brendan Eich to embed the Scheme language.<sup>[6]</sup>

Netscape management soon decided that the best option was for Eich to devise a new language, with syntax similar to Java and less like Scheme or other extant scripting languages.<sup>[5][6]</sup> Although the new language and its interpreter implementation were called LiveScript when first shipped as part of a Navigator beta in September 1995, the name was changed to JavaScript for the official release in December.<sup>[6][1][18]</sup>

The choice of the JavaScript name has caused confusion, implying that it is directly related to Java. At the time, the dot-com boom had begun and Java was the hot new language, so Eich considered the JavaScript name a marketing ploy by Netscape.<sup>[19]</sup>

## Adoption by Microsoft

Microsoft debuted Internet Explorer in 1995, leading to a browser war with Netscape. On the JavaScript front, Microsoft reverse-engineered the Navigator interpreter to create its own, called JScript.<sup>[20]</sup>

JScript was first released in 1996, alongside initial support for CSS and extensions to HTML. Each of these implementations was noticeably different from their counterparts in Navigator.<sup>[21][22]</sup> These differences made it difficult for developers to make their websites work well in both browsers, leading to widespread use of "best viewed in Netscape" and "best viewed in Internet Explorer" logos for several years.<sup>[21][23]</sup>

## The rise of JScript

In November 1996, Netscape submitted JavaScript to Ecma International, as the starting point for a standard specification that all browser vendors could conform to. This led to the official release of the first ECMAScript language specification in June 1997.

The standards process continued for a few years, with the release of ECMAScript 2 in June 1998 and ECMAScript 3 in December 1999. Work on ECMAScript 4 began in 2000.<sup>[20]</sup>

Meanwhile, Microsoft gained an increasingly dominant position in the browser market. By the early 2000s, Internet Explorer's market share reached 95%.<sup>[24]</sup> This meant that JScript became the de facto standard for client-side scripting on the Web.

Microsoft initially participated in the standards process and implemented some proposals in its JScript language, but eventually it stopped collaborating on Ecma work. Thus ECMAScript 4 was mothballed.

## Growth and standardization

During the period of Internet Explorer dominance in the early 2000s, client-side scripting was stagnant. This started to change in 2004, when the successor of Netscape, Mozilla, released the Firefox browser. Firefox was well received by many, taking significant market share from Internet Explorer.<sup>[25]</sup>

In 2005, Mozilla joined ECMA International, and work started on the ECMAScript for XML (E4X) standard. This led to Mozilla working jointly with Macromedia (later acquired by Adobe Systems), who were implementing E4X in their ActionScript 3 language, which was based on an ECMAScript 4 draft. The goal became standardizing ActionScript 3 as the new ECMAScript 4. To this end, Adobe Systems released the Tamarin implementation as an open source project. However, Tamarin and ActionScript 3 were too different from established client-side scripting, and without cooperation from Microsoft, ECMAScript 4 never reached fruition.

Meanwhile, very important developments were occurring in open-source communities not affiliated with ECMA work. In 2005, Jesse James Garrett released a white paper in which he coined the term Ajax and described a set of technologies, of which JavaScript was the backbone, to create web applications where data can be loaded in the background, avoiding the need for full page reloads. This sparked a renaissance period of JavaScript, spearheaded by open-source libraries and the communities that formed around them. Many new libraries were created, including jQuery, Prototype, Dojo Toolkit, and MooTools.

Google debuted its Chrome browser in 2008, with the V8 JavaScript engine that was faster than its competition.<sup>[26][27]</sup> The key innovation was just-in-time compilation (JIT),<sup>[28]</sup> so other browser vendors needed to overhaul their engines for JIT.<sup>[29]</sup>

In July 2008, these disparate parties came together for a conference in Oslo. This led to the eventual agreement in early 2009 to combine all relevant work and drive the language forward. The result was the ECMAScript 5 standard, released in December 2009.

## Reaching maturity

Ambitious work on the language continued for several years, culminating in an extensive collection of additions and refinements being formalized with the publication of ECMAScript 6 in 2015.<sup>[30]</sup>

The creation of Node.js in 2009 by Ryan Dahl sparked a significant increase in the usage of JavaScript outside of web browsers. Node combines the V8 engine, an event loop, and I/O APIs, thereby providing a stand-alone JavaScript runtime system.<sup>[31][32]</sup> As of 2018, Node had been used by millions of developers,<sup>[33]</sup> and npm had the most modules of any package manager in the world.<sup>[34]</sup>

The ECMAScript draft specification is currently maintained openly on GitHub, and editions are produced via regular annual snapshots.<sup>[35]</sup> Potential revisions to the language are vetted through a comprehensive proposal process.<sup>[36][37]</sup> Now, instead of edition numbers, developers check the status of upcoming features individually.<sup>[35]</sup>

The current JavaScript ecosystem has many libraries and frameworks, established programming practices, and substantial usage of JavaScript outside of web browsers. Plus, with the rise of single-page applications and other JavaScript-heavy websites, a number of transpilers have been created to aid the development process.<sup>[38]</sup>

## Trademark

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Except where otherwise noted, "JavaScript" is a trademark of Oracle Corporation in the United States.<sup>[39][40]</sup>

## Website client-side usage

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JavaScript is the dominant client-side scripting language of the Web, with 97% of websites using it for this purpose.<sup>[13]</sup> Scripts are embedded in or included from HTML documents and interact with the DOM. All major web browsers have a built-in JavaScript engine that executes the code on the user's device.

## Examples of scripted behavior

- Loading new web page content without reloading the page, via Ajax or a WebSocket. For example, users of social media can send and receive messages without leaving the current page.
- Web page animations, such as fading objects in and out, resizing, and moving them.
- Playing browser games.
- Controlling the playback of streaming media.
- Generating pop-up ads.
- Validating input values of a web form before the data is sent to a web server.
- Logging data about the user's behavior then sending it to a server. The website owner can use this data for analytics, ad tracking, and personalization.
- Redirecting a user to another page.

## Libraries and frameworks

Over 80% of websites use a third-party JavaScript library or web framework for their client-side scripting.<sup>[14]</sup>

jQuery is by far the most popular library, used by over 75% of websites.<sup>[14]</sup> Facebook created the React library for its website and later released it as open source; other sites, including Twitter, now use it. Likewise, the Angular framework created by Google for its websites, including YouTube and Gmail, is now an open source project used by others.<sup>[14]</sup>

In contrast, the term "Vanilla JS" has been coined for websites not using any libraries or frameworks, instead relying entirely on standard JavaScript functionality.<sup>[41]</sup>

## Other usage

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The use of JavaScript has expanded beyond its web browser roots. JavaScript engines are now embedded in a variety of other software systems, both for server-side website deployments and non-browser applications.

Initial attempts at promoting server-side JavaScript usage were Netscape Enterprise Server and Microsoft's Internet Information Services,<sup>[42][43]</sup> but they were small niches.<sup>[44]</sup> Server-side usage eventually started to grow in the late 2000s, with the creation of Node.js and other approaches.<sup>[44]</sup>

Electron, Cordova, React Native, and other application frameworks have been used to create many applications with behavior implemented in JavaScript. Other non-browser applications include Adobe Acrobat support for scripting PDF documents<sup>[45]</sup> and GNOME Shell extensions written in JavaScript.<sup>[46]</sup>

JavaScript has recently begun to appear in some embedded systems, usually by leveraging Node.js.<sup>[47][48][49]</sup>

## Features

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The following features are common to all conforming ECMAScript implementations unless explicitly specified otherwise.

## Imperative and structured

JavaScript supports much of the structured programming syntax from C (e.g., `if` statements, `while` loops, `switch` statements, `do while` loops, etc.). One partial exception is scoping: originally JavaScript only had function scoping with `var`; then block scoping was added in ECMAScript 2015 with the keywords `let` and `const`. Like C, JavaScript makes a distinction between expressions and statements. One syntactic difference from C is automatic semicolon insertion, which allow semicolons (which terminate statements) to be omitted.<sup>[50]</sup>

## Weakly typed

JavaScript is weakly typed, which means certain types are implicitly cast depending on the operation used.<sup>[51]</sup>

- The binary `+` operator casts both operands to a string unless both operands are numbers. This is because the addition operator doubles as a concatenation operator
- The binary `-` operator always casts both operands to a number
- Both unary operators (`+`, `-`) always cast the operand to a number

Values are cast to strings like the following:<sup>[51]</sup>

- Strings are left as-is
- Numbers are converted to their string representation
- Arrays have their elements cast to strings after which they are joined by commas (`,`)
- Other objects are converted to the string `[object Object]` where `Object` is the name of the constructor of the object

Values are cast to numbers by casting to strings and then casting the strings to numbers. These processes can be modified by defining `toString` and `valueOf` functions on the prototype for string and number casting respectively.

JavaScript has received criticism for the way it implements these conversions as the complexity of the rules can be mistaken for inconsistency.<sup>[52][51]</sup> For example, when adding a number to a string, the number will be cast to a string before performing concatenation, but when subtracting a number from a string, the string is cast to a number before performing subtraction.

JavaScript type conversions

left operand	operator	right operand	result
<code>[]</code> (empty array)	<code>+</code>	<code>[]</code> (empty array)	<code>""</code> (empty string)
<code>[]</code> (empty array)	<code>+</code>	<code>{}</code> (empty object)	<code>"[object Object]"</code> (string)
<code>false</code> (boolean)	<code>+</code>	<code>[]</code> (empty array)	<code>"false"</code> (string)
<code>"123"</code> (string)	<code>+</code>	<code>1</code> (number)	<code>"1231"</code> (string)
<code>"123"</code> (string)	<code>-</code>	<code>1</code> (number)	<code>122</code> (number)

Often also mentioned is `{}` `+` `[]` resulting in `0` (number). This is misleading: the `{}` is interpreted as an empty code block instead of an empty object, and the empty array is cast to a number by the remaining unary `+` operator. If you wrap the expression in parentheses (`{}` `+` `[]`)

the curly brackets are interpreted as an empty object and the result of the expression is "[object Object]" as expected.<sup>[51]</sup>

## Dynamic

### Typing

JavaScript is dynamically typed like most other scripting languages. A type is associated with a value rather than an expression. For example, a variable initially bound to a number may be reassigned to a string.<sup>[53]</sup> JavaScript supports various ways to test the type of objects, including duck typing.<sup>[54]</sup>

### Run-time evaluation

JavaScript includes an eval function that can execute statements provided as strings at run-time.

## Object-orientation (prototype-based)

Prototypal inheritance in JavaScript is described by Douglas Crockford as:

You make prototype objects, and then ... make new instances. Objects are mutable in JavaScript, so we can augment the new instances, giving them new fields and methods. These can then act as prototypes for even newer objects. We don't need classes to make lots of similar objects... Objects inherit from objects. What could be more object oriented than that?<sup>[55]</sup>

In JavaScript, an object is an associative array, augmented with a prototype (see below); each key provides the name for an object property, and there are two syntactical ways to specify such a name: dot notation (`obj.x = 10`) and bracket notation (`obj['x'] = 10`). A property may be added, rebound, or deleted at run-time. Most properties of an object (and any property that belongs to an object's prototype inheritance chain) can be enumerated using a `for...in` loop.

### Prototypes

JavaScript uses prototypes where many other object-oriented languages use classes for inheritance.<sup>[56]</sup> It is possible to simulate many class-based features with prototypes in JavaScript.<sup>[57]</sup>

### Functions as object constructors

Functions double as object constructors, along with their typical role. Prefixing a function call with *new* will create an instance of a prototype, inheriting properties and methods from the constructor (including properties from the `Object` prototype).<sup>[58]</sup> ECMAScript 5 offers the `Object.create` method, allowing explicit creation of an instance without automatically inheriting from the `Object` prototype (older environments can assign the prototype to `null`).<sup>[59]</sup> The constructor's `prototype` property determines the object used for the new object's internal prototype. New methods can be added by modifying the prototype of the function used as a constructor. JavaScript's built-in constructors, such as `Array` or `Object`, also have prototypes that can be modified. While it is possible to modify the `Object` prototype, it is generally considered bad practice because most objects in JavaScript will inherit methods and properties from the `Object` prototype, and they may not expect the prototype to be modified.<sup>[60]</sup>

### Functions as methods

Unlike many object-oriented languages, there is no distinction between a function definition and a method definition. Rather, the distinction occurs during function calling; when a function is called as a method of an object, the function's local *this* keyword is bound to that object for that invocation.

## Functional

A function is first-class; a function is considered to be an object.<sup>[61]</sup> As such, a function may have properties and methods, such as `.call()` and `.bind()`.<sup>[62]</sup> A *nested* function is a function defined within another function. It is created each time the outer function is invoked. In addition, each nested function forms a lexical closure: the lexical scope of the outer function (including any constant, local variable, or argument value) becomes part of the internal state of each inner function object, even after execution of the outer function concludes.<sup>[63]</sup> JavaScript also supports anonymous functions.

## Delegative

JavaScript supports implicit and explicit delegation.

### Functions as roles (Traits and Mixins)

JavaScript natively supports various function-based implementations of Role<sup>[64]</sup> patterns like Traits<sup>[65][66]</sup> and Mixins.<sup>[67]</sup> Such a function defines additional behavior by at least one method bound to the `this` keyword within its function body. A Role then has to be delegated explicitly via `call` or `apply` to objects that need to feature additional behavior that is not shared via the prototype chain.

### Object composition and inheritance

Whereas explicit function-based delegation does cover composition in JavaScript, implicit delegation already happens every time the prototype chain is walked in order to, e.g., find a method that might be related to but is not directly owned by an object. Once the method is found it gets called within this object's context. Thus inheritance in JavaScript is covered by a delegation automatism that is bound to the prototype property of constructor functions.

## Miscellaneous

JS is a zero-index language.

### Run-time environment

JavaScript typically relies on a run-time environment (e.g., a web browser) to provide objects and methods by which scripts can interact with the environment (e.g., a web page DOM). These environments are single-threaded. JavaScript also relies on the run-time environment to provide the ability to include/import scripts (e.g., HTML `<script>` elements). This is not a language feature per se, but it is common in most JavaScript implementations. JavaScript processes messages from a queue one at a time. JavaScript calls a function associated with each new message, creating a call stack frame with the function's arguments and local variables. The call stack shrinks and grows based on the function's needs. When the call stack is empty upon function completion, JavaScript proceeds to the next message in the queue. This is called the event loop, described as "run to completion" because each message is fully processed before the next message is considered. However, the language's concurrency model describes the event loop as non-blocking: program input/output is performed using events and callback functions. This means, for instance, that JavaScript can process a mouse click while waiting for a database query to return information.<sup>[68]</sup>

### Variadic functions

An indefinite number of parameters can be passed to a function. The function can access them through formal parameters and also through the local arguments object. Variadic functions can also be created by using the bind ([https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global\\_Objects/Function/bind](https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Function/bind)) method.



## Array and object literals

Like many scripting languages, arrays and objects (associative arrays in other languages) can each be created with a succinct shortcut syntax. In fact, these literals form the basis of the JSON data format.

## Regular expressions

JavaScript also supports regular expressions in a manner similar to Perl, which provide a concise and powerful syntax for text manipulation that is more sophisticated than the built-in string functions.<sup>[69]</sup>

## Promises

JavaScript also supports promises, which are a way of handling asynchronous operations. There is a built-in Promise object that gives access to a lot of functionalities for handling promises, and defines how they should be handled. It allows one to associate handlers with an asynchronous action's eventual success value or failure reason. This lets asynchronous methods return values like synchronous methods: instead of immediately returning the final value, the asynchronous method returns a promise to supply the value at some point in the future. Recently, combinator methods were introduced in the JavaScript specification, which allows developers to combine multiple JavaScript promises and do operations based on different scenarios. The methods introduced are: Promise.race, Promise.all, Promise.allSettled and Promise.any.

## Vendor-specific extensions

Historically, some JavaScript engines supported these non-standard features:

- conditional `catch` clauses (like Java)
- array comprehensions and generator expressions (like Python)
- concise function expressions (`function(args) expr`; this experimental syntax predated arrow functions)
- ECMAScript for XML (E4X), an extension that adds native XML support to ECMAScript (unsupported in Firefox since version 21<sup>[70]</sup>)

# Syntax

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## Simple examples

Variables in JavaScript can be defined using either the `var`,<sup>[71]</sup> `let`<sup>[72]</sup> or `const`<sup>[73]</sup> keywords.

```
// Declares a function-scoped variable named `x`, and implicitly assigns the
// special value `undefined` to it. Variables without value are automatically
// set to undefined.
var x;

// Variables can be manually set to `undefined` like so
var x2 = undefined;

// Declares a block-scoped variable named `y`, and implicitly sets it to
// `undefined`. The `let` keyword was introduced in ECMAScript 2015.
let y;

// Declares a block-scoped, un-reassignable variable named `z`, and sets it to
// a string literal. The `const` keyword was also introduced in ECMAScript 2015,
// and must be explicitly assigned to.

// The keyword `const` means constant, hence the variable cannot be reassigned
// as the value is `constant`.
const z = "this value cannot be reassigned!";
```

```
// Declares a variable named `myNumber`, and assigns a number literal (the value
// `2`) to it.
let myNumber = 2;

// Reassigns `myNumber`, setting it to a string literal (the value `foo`).
// JavaScript is a dynamically-typed language, so this is legal.
myNumber = "foo";
```

Note the comments in the example above, all of which were preceded with two forward slashes.

There is no built-in Input/output functionality in JavaScript; the run-time environment provides that. The ECMAScript specification in edition 5.1 mentions:<sup>[74]</sup>

indeed, there are no provisions in this specification for input of external data or output of computed results.

However, most runtime environments have a `console` object<sup>[75]</sup> that can be used to print output. Here is a minimalist Hello World program in JavaScript:

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

A simple recursive function:

```
function factorial(n) {
  if (n === 0)
    return 1; // 0! = 1

  return n * factorial(n - 1);
}

factorial(3); // returns 6
```

An anonymous function (or lambda):

```
function counter() {
  let count = 0;

  return function() {
    return ++count;
  };
}

let closure = counter();
closure(); // returns 1
closure(); // returns 2
closure(); // returns 3
```

This example shows that, in JavaScript, function closures capture their non-local variables by reference.

Arrow functions were first introduced in 6th Edition - ECMAScript 2015. They shorten the syntax for writing functions in JavaScript. Arrow functions are anonymous, so a variable is needed to refer to them in order to invoke them after their creation.

Example of arrow function:

```
// Arrow functions let us omit the `function` keyword.
// Here `long_example` points to an anonymous function value.
```

```

const long_example = (input1, input2) => {
  console.log("Hello, World!");
  const output = input1 + input2;

  return output;
};

// If there are no braces, the arrow function simply returns the expression
// So here it's (input1 + input2)
const short_example = (input1, input2) => input1 + input2;

long_example(2, 3); // Prints "Hello, World!" and returns 5
short_example(2, 5); // Returns 7

// If an arrow function only has one parameter, the parentheses can be removed.
const no_parentheses = input => input + 2;

no_parentheses(3); // Returns 5

```

In JavaScript, objects are created in the same way as functions; this is known as a function object.

Object example:

```

function Ball(r) {
  this.radius = r; // the "r" argument is local to the ball object
  this.area = Math.PI * (r ** 2); // parentheses don't do anything but clarify

  // objects can contain functions ("method")
  this.show = function() {
    drawCircle(this.radius); // references another function (that draws a circle)
  };
}

let myBall = new Ball(5); // creates a new instance of the ball object with radius 5
myBall.radius++; // object properties can usually be modified from the outside
myBall.show(); // using the inherited "show" function

```

Variadic function demonstration (arguments is a special variable):<sup>[76]</sup>

```

function sum() {
  let x = 0;

  for (let i = 0; i < arguments.length; ++i)
    x += arguments[i];

  return x;
}

sum(1, 2); // returns 3
sum(1, 2, 3); // returns 6

```

Immediately-invoked function expressions are often used to create closures. Closures allow gathering properties and methods in a namespace and making some of them private:

```

let counter = (function() {
  let i = 0; // private property

  return { // public methods
    get: function() {
      alert(i);
    },
    set: function(value) {
      i = value;
    },
    increment: function() {
      alert(++i);
    }
  };
})(); // module

```

```

counter.get();      // shows 0
counter.set(6);
counter.increment(); // shows 7
counter.increment(); // shows 8

```

## Exporting and Importing modules in JavaScript<sup>[77]</sup>

Export example:

```

/* mymodule.js */
// This function remains private, as it is not exported
let sum = (a, b) => {
  return a + b;
}

// Export variables
export let name = 'Alice';
export let age = 23;

// Export named functions
export function add(num1, num2) {
  return num1 + num2;
}

// Export class
export class Multiplication {
  constructor(num1, num2) {
    this.num1 = num1;
    this.num2 = num2;
  }

  add() {
    return sum(this.num1, this.num2);
  }
}

```

Import example:

```

// Import one property
import { add } from './mymodule.js';

console.log(add(1, 2)); // 3

// Import multiple properties
import { name, age } from './mymodule.js';
console.log(name, age);
//> "Alice", 23

// Import all properties from a module
import * from './module.js'
console.log(name, age);
//> "Alice", 23
console.log(add(1,2));
//> 3

```

## More advanced example

This sample code displays various JavaScript features.

```

/* Finds the lowest common multiple (LCM) of two numbers */
function LCMCalculator(x, y) { // constructor function
  const checkInt = function(x) { // inner function
    if (x % 1 !== 0)
      throw new TypeError(x + "is not an integer"); // var a = mouseX

    return x;
  }
}

```

```

};

this.a = checkInt(x)
// semicolons ^^^ are optional, a newline is enough
this.b = checkInt(y);
}
// The prototype of object instances created by a constructor is
// that constructor's "prototype" property.
LCMCalculator.prototype = { // object literal
  constructor: LCMCalculator, // when reassigning a prototype, set the constructor property
  appropriately
  gcd: function() { // method that calculates the greatest common divisor
    // Euclidean algorithm:
    let a = Math.abs(this.a), b = Math.abs(this.b), t;

    if (a < b) {
      // swap variables
      // t = b; b = a; a = t;
      [a, b] = [b, a]; // swap using destructuring assignment (ES6)
    }

    while (b !== 0) {
      t = b;
      b = a % b;
      a = t;
    }

    // Only need to calculate GCD once, so "redefine" this method.
    // (Actually not redefinition—it's defined on the instance itself,
    // so that this.gcd refers to this "redefinition" instead of LCMCalculator.prototype.gcd.
    // Note that this leads to a wrong result if the LCMCalculator object members "a" and/or "b" are
    altered afterwards.)
    // Also, 'gcd' === "gcd", this['gcd'] === this.gcd
    this['gcd'] = function() {
      return a;
    };

    return a;
  },

  // Object property names can be specified by strings delimited by double (") or single (') quotes.
  "lcm": function() {
    // Variable names do not collide with object properties, e.g., |lcm| is not |this.lcm|.
    // not using |this.a*this.b| to avoid FP precision issues
    let lcm = this.a / this.gcd() * this.b;

    // Only need to calculate lcm once, so "redefine" this method.
    this.lcm = function() {
      return lcm;
    };

    return lcm;
  },

  // Methods can also be declared using es6 syntax
  toString() {
    // Using both es6 template literals and the (+) operator to concatenate values
    return `LCMCalculator: a = ${this.a}, b = ` + this.b;
  }
};

// Define generic output function; this implementation only works for Web browsers
function output(x) {
  document.body.appendChild(document.createTextNode(x));
  document.body.appendChild(document.createElement('br'));
}

// Note: Array's map() and forEach() are defined in JavaScript 1.6.
// They are used here to demonstrate JavaScript's inherent functional nature.
[
  [25, 55],
  [21, 56],
  [22, 58],
  [28, 56]
].map(function(pair) { // array literal + mapping function
  return new LCMCalculator(pair[0], pair[1]);
}).sort((a, b) => a.lcm() - b.lcm()) // sort with this comparative function; => is a shorthand form of a
function, called "arrow function"

```

```
.forEach(printResult);  
  
function printResult(obj) {  
    output(obj + ", gcd = " + obj.gcd() + ", lcm = " + obj.lcm());  
}
```

The following output should be displayed in the browser window.

```
LCMCalculator: a = 28, b = 56, gcd = 28, lcm = 56  
LCMCalculator: a = 21, b = 56, gcd = 7, lcm = 168  
LCMCalculator: a = 25, b = 55, gcd = 5, lcm = 275  
LCMCalculator: a = 22, b = 58, gcd = 2, lcm = 638
```

## Security

JavaScript and the DOM provide the potential for malicious authors to deliver scripts to run on a client computer via the Web. Browser authors minimize this risk using two restrictions. First, scripts run in a sandbox in which they can only perform Web-related actions, not general-purpose programming tasks like creating files. Second, scripts are constrained by the same-origin policy: scripts from one Web site do not have access to information such as usernames, passwords, or cookies sent to another site. Most JavaScript-related security bugs are breaches of either the same origin policy or the sandbox.

There are subsets of general JavaScript—ADsafe, Secure ECMAScript (SES)—that provide greater levels of security, especially on code created by third parties (such as advertisements).<sup>[78][79]</sup> Closure Toolkit is another project for safe embedding and isolation of third-party JavaScript and HTML.<sup>[80]</sup>

Content Security Policy is the main intended method of ensuring that only trusted code is executed on a Web page.

### Cross-site vulnerabilities

A common JavaScript-related security problem is cross-site scripting (XSS), a violation of the same-origin policy. XSS vulnerabilities occur when an attacker can cause a target Web site, such as an online banking website, to include a malicious script in the webpage presented to a victim. The script in this example can then access the banking application with the privileges of the victim, potentially disclosing secret information or transferring money without the victim's authorization. A solution to XSS vulnerabilities is to use *HTML escaping* whenever displaying untrusted data.

Some browsers include partial protection against *reflected* XSS attacks, in which the attacker provides a URL including malicious script. However, even users of those browsers are vulnerable to other XSS attacks, such as those where the malicious code is stored in a database. Only correct design of Web applications on the server side can fully prevent XSS.

XSS vulnerabilities can also occur because of implementation mistakes by browser authors.<sup>[81]</sup>

Another cross-site vulnerability is cross-site request forgery (CSRF). In CSRF, code on an attacker's site tricks the victim's browser into taking actions the user did not intend at a target site (like transferring money at a bank). When target sites rely solely on cookies for request authentication, requests originating from code on the attacker's site can carry the same valid login credentials of the initiating user. In general, the solution to CSRF is to require an authentication value in a hidden form field, and not only in the cookies, to authenticate any request that might have lasting effects. Checking the HTTP Referrer header can also help.

"JavaScript hijacking" is a type of CSRF attack in which a `<script>` tag on an attacker's site exploits a page on the victim's site that returns private information such as JSON or JavaScript. Possible solutions include:

- requiring an authentication token in the POST and GET parameters for any response that returns private information.

## Misplaced trust in the client

Developers of client-server applications must recognize that untrusted clients may be under the control of attackers. The application author cannot assume that their JavaScript code will run as intended (or at all) because any secret embedded in the code could be extracted by a determined adversary. Some implications are:

- Web site authors cannot perfectly conceal how their JavaScript operates because the raw source code must be sent to the client. The code can be obfuscated, but obfuscation can be reverse-engineered.
- JavaScript form validation only provides convenience for users, not security. If a site verifies that the user agreed to its terms of service, or filters invalid characters out of fields that should only contain numbers, it must do so on the server, not only the client.
- Scripts can be selectively disabled, so JavaScript cannot be relied on to prevent operations such as right-clicking on an image to save it.<sup>[82]</sup>
- It is considered very bad practice to embed sensitive information such as passwords in JavaScript because it can be extracted by an attacker.<sup>[83]</sup>

## Misplaced trust in developers

Package management systems such as npm and Bower are popular with JavaScript developers. Such systems allow a developer to easily manage their program's dependencies upon other developers' program libraries. Developers trust that the maintainers of the libraries will keep them secure and up to date, but that is not always the case. A vulnerability has emerged because of this blind trust. Relied-upon libraries can have new releases that cause bugs or vulnerabilities to appear in all programs that rely upon the libraries. Inversely, a library can go unpatched with known vulnerabilities out in the wild. In a study done looking over a sample of 133k websites, researchers found 37% of the websites included a library with at least one known vulnerability.<sup>[84]</sup> "The median lag between the oldest library version used on each website and the newest available version of that library is 1,177 days in ALEXA, and development of some libraries still in active use ceased years ago."<sup>[84]</sup> Another possibility is that the maintainer of a library may remove the library entirely. This occurred in March 2016 when Azer Koçulu removed his repository from npm. This caused tens of thousands of programs and websites depending upon his libraries to break.<sup>[85][86]</sup>

## Browser and plugin coding errors

JavaScript provides an interface to a wide range of browser capabilities, some of which may have flaws such as buffer overflows. These flaws can allow attackers to write scripts that would run any code they wish on the user's system. This code is not by any means limited to another JavaScript application. For example, a buffer overrun exploit can allow an attacker to gain access to the operating system's API with superuser privileges.

These flaws have affected major browsers including Firefox,<sup>[87]</sup> Internet Explorer,<sup>[88]</sup> and Safari.<sup>[89]</sup>

Plugins, such as video players, [Adobe Flash](#), and the wide range of [ActiveX](#) controls enabled by default in Microsoft Internet Explorer, may also have flaws exploitable via JavaScript (such flaws have been exploited in the past).<sup>[90][91]</sup>

In Windows Vista, Microsoft has attempted to contain the risks of bugs such as buffer overflows by running the Internet Explorer process with limited privileges.<sup>[92]</sup> [Google Chrome](#) similarly confines its page renderers to their own "sandbox".

## Sandbox implementation errors

Web browsers are capable of running JavaScript outside the sandbox, with the privileges necessary to, for example, create or delete files. Such privileges are not intended to be granted to code from the Web.

Incorrectly granting privileges to JavaScript from the Web has played a role in vulnerabilities in both Internet Explorer<sup>[93]</sup> and Firefox.<sup>[94]</sup> In Windows XP Service Pack 2, Microsoft demoted JScript's privileges in Internet Explorer.<sup>[95]</sup>

[Microsoft Windows](#) allows JavaScript source files on a computer's hard drive to be launched as general-purpose, non-sandboxed programs (see: [Windows Script Host](#)). This makes JavaScript (like [VBScript](#)) a theoretically viable vector for a [Trojan horse](#), although JavaScript Trojan horses are uncommon in practice.<sup>[96]</sup>

## Hardware vulnerabilities

In 2015, a JavaScript-based proof-of-concept implementation of a [rowhammer](#) attack was described in a paper by security researchers.<sup>[97][98][99][100]</sup>

In 2017, a JavaScript-based attack via browser was demonstrated that could bypass [ASLR](#). It's called "ASLR⊕Cache" or AnC.<sup>[101][102]</sup>

In 2018, the paper that announced the [Spectre](#) attacks against Speculative Execution in Intel and other processors included a JavaScript implementation.<sup>[103]</sup>

## Development tools

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Important tools have evolved with the language.

- Every major web browser has built-in [web development tools](#), including a JavaScript [debugger](#).
- [Static program analysis](#) tools, such as [ESLint](#) and [JSLint](#), scan JavaScript code for conformance to a set of standards and guidelines.
- Some browsers have built-in [profilers](#). Stand-alone profiling libraries have also been created, such as [benchmark.js](#) and [jsbench](#).<sup>[104][105]</sup>
- Many [text editors](#) have syntax highlighting support for JavaScript code.

## Related technologies

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### Java



A common misconception is that JavaScript is the same as Java. Both indeed have a C-like syntax (the C language being their most immediate common ancestor language). They are also typically sandboxed (when used inside a browser), and JavaScript was designed with Java's syntax and standard library in mind. In particular, all Java keywords were reserved in original JavaScript, JavaScript's standard library follows Java's naming conventions, and JavaScript's **Math** and **Date** objects are based on classes from Java 1.0<sup>[106]</sup>.

Java and JavaScript both first appeared in 1995, but Java was developed by James Gosling of Sun Microsystems, and JavaScript by Brendan Eich of Netscape Communications.

The differences between the two languages are more prominent than their similarities. Java has static typing, while JavaScript's typing is dynamic. Java is loaded from compiled bytecode, while JavaScript is loaded as human-readable source code. Java's objects are class-based, while JavaScript's are prototype-based. Finally, Java did not support functional programming until Java 8, while JavaScript has done so from the beginning, being influenced by Scheme.

## JSON

JSON, or JavaScript Object Notation, is a general-purpose data interchange format that is defined as a subset of JavaScript's object literal syntax.

## WebAssembly

Since 2017, web browsers have supported WebAssembly, a binary format that enables a JavaScript engine to execute performance-critical portions of web page scripts close to native speed.<sup>[107]</sup> WebAssembly code runs in the same sandbox as regular JavaScript code.

asm.js is a subset of JavaScript that served as the forerunner of WebAssembly.<sup>[108]</sup>

## Transpilers

JavaScript is the dominant client-side language of the Web, and many websites are script-heavy. Thus transpilers have been created to convert code written in other languages, which can aid the development process.<sup>[38]</sup>

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## Further reading

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- Zakas, Nicholas. *Principles of Object-Oriented JavaScript*, 1st edition. No Starch Press, 2014. 120 pages. ISBN 978-1593275402.

## External links

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- JavaScript (<https://curlie.org/Computers/Programming/Languages/JavaScript/>) at Curlie
  - Douglas Crockford's video lectures on JavaScript (<https://www.youtube.com/playlist?list=PL62E185BB8577B63D>)
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