Javascript as a client-side programming language

Javascript can run as a client-side or server-side language

Client-side: javascript is embedded in html page (in <script>…</script>), which is run in a web browser

Server-side: Node (based on Google’s V8 engine) is the compiler

# Javascript language

# Run Javascript with HTML

## Run Javascript in browser or Node

## Where to put Javascript

In HTML, JavaScript code is inserted between <script> and </script> tags.

<script>  
document.getElementById("demo").innerHTML = "My First JavaScript";  
</script>

**You can place any number of scripts in an HTML document.**

Scripts can be placed in the <body>, or in the <head> section of an HTML page, or in both.

Scripts can also be placed in external files of extension .js:

External file: myScript.js

function myFunction() {  
  document.getElementById("demo").innerHTML = "Paragraph changed.";  
}

External scripts are practical when the same code is used in many different web pages.

To use an external script, put the name of the script file in the src (source) attribute of a <script> tag:

Example: Instead of <script> …code… </script>, put the content …code… in an external file and add the following line

<script src="myScript.js"></script>

You can place an external script reference in <head> or <body> as you like.

The script will behave as if it was located exactly where the <script> tag is located.

# JavaScript Interact with users

## alert() to show a message, prompt() for input, confirm() for yes/no confirmation

As we’ll be using the browser as our demo environment, let’s see a couple of functions to interact with the user: alert, prompt and confirm.

### [alert](https://javascript.info/alert-prompt-confirm" \l "alert)

It shows a message and waits for the user to press “OK”.

For example:

alert("Hello");

The mini-window with the message is called a modal window. The word “modal” means that the visitor can’t interact with the rest of the page, press other buttons, etc, until they have dealt with the window. In this case – until they press “OK”.

### [prompt](https://javascript.info/alert-prompt-confirm" \l "prompt)

The function prompt accepts two arguments:

result = prompt(title, [default]);

It shows a modal window with a text message, an input field for the visitor, and the buttons OK/Cancel.

**Title** The text to show the visitor.

**Default** An optional second parameter, the initial value for the input field.

**The square brackets in syntax [...]**

The square brackets around default in the syntax above denote that the parameter is optional, not required.

The visitor can type something in the prompt input field and press OK. Then we get that text in the result. Or they can cancel the input by pressing Cancel or hitting the Esc key, then we get null as the result.

The call to prompt returns the text from the input field or null if the input was canceled.

For instance:

let age = prompt('How old are you?', 100);

alert(`You are ${age} years old!`); // You are 100 years old!

**In IE: always supply a default**

The second parameter is optional, but if we don’t supply it, Internet Explorer will insert the text "undefined" into the prompt.

Run this code in Internet Explorer to see:

let test = prompt("Test");

So, for prompts to look good in IE, we recommend always providing the second argument:

let test = prompt("Test", ''); // <-- for IE

### [confirm](https://javascript.info/alert-prompt-confirm" \l "confirm)

The syntax:

result = confirm(question);

The function confirm shows a modal window with a question and two buttons: OK and Cancel.

The result is true if OK is pressed and false otherwise.

For example:

let isBoss = confirm("Are you the boss?");

alert( isBoss ); // true if OK is pressed

## JavaScript Output

JavaScript can "display" data in different ways:

* Writing into an HTML element, using innerHTML.
* Writing into the HTML output using document.write().
* Writing into an alert box, using window.alert().
* Writing into the browser console, using console.log().

### Using innerHTML

To access an HTML element, JavaScript can use the document.getElementById(id) method.

The id attribute defines the HTML element. The innerHTML property defines the HTML content:

Example

<!DOCTYPE html>  
<html>  
<body>  
  
<h1>My First Web Page</h1>  
<p>My First Paragraph</p>  
  
<p id="demo"></p>  
  
<script>  
document.getElementById("demo").innerHTML = 5 + 6;  
</script>  
  
</body>  
</html>

Changing the innerHTML property of an HTML element is a common way to display data in HTML.

### Using document.write()

For testing purposes, it is convenient to use document.write():

Example

<!DOCTYPE html>  
<html>  
<body>  
  
<h1>My First Web Page</h1>  
<p>My first paragraph.</p>  
  
<script>  
document.write(5 + 6);  
</script>  
  
</body>  
</html>

Using document.write() **after** an HTML document is loaded, will **delete all existing HTML**:

The following Example is different from the above in that document.write() is called after the document is loaded.

<!DOCTYPE html>  
<html>  
<body>  
  
<h1>My First Web Page</h1>  
<p>My first paragraph.</p>  
  
<button type="button" onclick="document.write(5 + 6)">Try it</button>  
  
</body>  
</html>

The document.write() method should only be used for testing.

### Using window.alert()

You can use an alert box to display data:

Example

<!DOCTYPE html>  
<html>  
<body>  
  
<h1>My First Web Page</h1>  
<p>My first paragraph.</p>  
  
<script>  
window.alert(5 + 6);  
</script>  
  
</body>  
</html>

You can skip the window keyword.

In JavaScript, the window object is the global scope object, that means that variables, properties, and methods by default belong to the window object. This also means that specifying the window keyword is optional:

Example

<!DOCTYPE html>  
<html>  
<body>  
  
<h1>My First Web Page</h1>  
<p>My first paragraph.</p>  
  
<script>  
alert(5 + 6);  
</script>  
  
</body>  
</html>

### Using console.log()

For debugging purposes, you can call the console.log() method in the browser to display data.

Example

<!DOCTYPE html>  
<html>  
<body>  
  
<script>  
console.log(5 + 6);  
</script>  
  
</body>  
</html>

### JavaScript Print

JavaScript does not have any print object or print methods.

You cannot access output devices from JavaScript.

The only exception is that you can call the window.print() method in the browser to print the content of the current window.

Example

<!DOCTYPE html>  
<html>  
<body>  
  
<button onclick="window.print()">Print this page</button>  
  
</body>  
</html>

# JavaScript Syntax

Javascript statements are executed, one by one, in the same order as they are written.

Semicolons separate JavaScript statements.

JavaScript ignores multiple spaces. You can add white space to your script to make it more readable.

Two types of values in Javascript: Fixed values (Literals) and Variable values (variables)

Literals:

* **Numbers** are written with or without decimals
* **Strings** are text, written within double or single quotes

Variables: JavaScript uses the var keyword to **declare** variables. An **equal sign** is used to **assign values** to variables.

JavaScript Expressions, e.g. 5\*10, x+3, without assignment will be displayed.

JavaScript Identifiers (names) are used to name variables, functions: the first character must be a letter, or an underscore (\_), or a dollar sign ($).

JavaScript is case-sensitive and uses lower camel case.

# Data types

## Primitive (boolean, number, string, undefined, null, symbol) and Object

All values belong to one of 8 types:

|  |  |
| --- | --- |
| **Type** | **Values of the Type** |
| Undefined | Only one value: undefined. Means “I don’t know,” “I don’t care”, or “None of your business.” |
| Null | Only one value: null. Means “no value.” |
| Boolean | Only two values: true and false. |
| Number | The IEEE 754 64-bit floating point values. Values that are integers can be expressed in binary, octal, decimal, or hex; non-integers must be expressed in decimal. Examples:   * 8 * 7.23342 * 6.02e23 * 0xff3e * 0b11010100001010 * 0o237 * Infinity * NaN |
| BigInt | Arbitrary-precision integers. Needed because the Number type can not represent most integers with a magnitude above 9007199254740992. Examples:   * 3n * 2098321521257182187525313919187155317815353517831735173173551735173n |
| String | Immutable sequences of zero or more UTF-16 code units. You can delimit them with apostrophes, quotation marks, or backticks. Examples:   * "hello" * "She said 'I don’t think so 😎'... (╯°□°）╯︵ ┻━┻)" * 'x = "4"' * "abc\tdef\"\r\nghi\n🏄‍♀️🏀\n" * "Olé" * "Ol\xe9" * 'Will I?\u043d\u0435\u0442\u263a' * `The sum of ${x} and ${y} is probably ${x + y}`   Only backtick-delimited literals can span lines and support interpolation. |
| Symbol | Unique things. Every time you create a symbol, you get a new thing, different from all other symbols. This is not necessarily true of strings. Examples:   * Symbol() * Symbol('dog') * Symbol('dog') // different from the one above |
| Object | Everything that isn’t one of the above types. Examples:   * {} * {latitude: 74.2, longitude: -153.11} * [true, true, {last: false, value: 'okay'}, [0, 0, 2]] * new Set([5, 1, 2]) * new Date(2000, 12, 31) * (x, y) => x \* x + y \* y * /Boo+m!?/gi   Certain kinds of objects, such as arrays, functions and regular expressions have special syntactic forms, but to JavaScript they are just considered to have the type Object. |

## Primitve are immutable, Objects are mutable

A **mutable object** is an object whose state can be modified after it is created.

**Immutables** are the objects whose state cannot be changed once the object is created.

In [JavaScript](https://developer.mozilla.org/en-US/docs/Glossary/JavaScript), only [objects](https://developer.mozilla.org/en-US/docs/Glossary/Object) and [arrays](https://developer.mozilla.org/en-US/docs/Glossary/Array) are mutable. **Strings and Numbers** are **Immutable**. Lets understand this with an example:

var immutableString = "Hello";

// In the above code, a new object with string value is created.

immutableString = immutableString + "World";

// We are now appending "World" to the existing value.

On appending the "immutableString" with a string value, following events occur:

1. Existing value of "immutableString" is retrieved
2. "World" is appended to the existing value of "immutableString"
3. The resultant value is then allocated to a new block of memory
4. "immutableString" object now points to the newly created memory space
5. Previously created memory space is now available for garbage collection.

## Objects

An instance of Object data type is called an object, which is a collection of related variables and functions.

### Create an object

There are two ways to create an object:

* Create an object literal by writing out the object content:

const person = {

name: ['Bob', 'Smith'],

age: 32,

gender: 'male',

interests: ['music', 'skiing'],

bio: function() {

alert(this.name[0] + ' ' + this.name[1] + ' is ' + this.age + ' years old. He likes ' + this.interests[0] + ' and ' + this.interests[1] + '.');

},

greeting: function() {

alert('Hi! I\'m ' + this.name[0] + '.');

}

};

* Instantiate an object of Object class:

let person = new Object();

person.name = "Nicholas";

person.age = 29;

It’s also possible to create an object with only the default properties and methods using object literal notation by leaving the space between the curly braces empty, such as this for the above example:

let person = {}; // same as new Object()

person.name = "Nicholas";

person.age = 29;

Note: A member of an object can be another object.

For example, try changing the name member from

name: ['Bob', 'Smith'],

to

name : {

first: 'Bob',

last: 'Smith'

},

Here we are effectively creating a **sub-namespace**. This sounds complex, but really it's not — to access these items you just need to chain the extra step onto the end with another dot. Try these in the JS console:

person.name.first

person.name.last

### Get/Set data of an object by dot or bracket notation

To get data of an object:

Dot

person.name

person.name[0]

person.age

person.interests[1]

person.bio()

person.greeting()

Bracket notation

person['age']

To set data of an object:

person.age = 45;

person['name']['last'] = 'Cratchit';

Setting members doesn't just stop at updating the values of existing properties and methods; you can also create completely new members. Try these in the JS console:

person['eyes'] = 'hazel';

person.farewell = function() { alert("Bye everybody!"); }

**Bracket notation can be used to create dynamically new data members**

For example: create a new data member whose name, value is given dynamically by myDataName, myDataValue:

let myDataName = nameInput.value;

let myDataValue = nameValue.value;

We could then add this new member name and value to the person object like this:

person[myDataName] = myDataValue;

### this keyword refers to the current object

The this keyword refers to the current object the code is being written inside — so in the example of person object above, this is equivalent to person.

greeting: function() {

alert('Hi! I\'m ' + this.name.first + '.');

}

### Global object

The global object provides variables and functions that are available anywhere. By default, those that are built into the language or the environment.

In a browser it is named window, for Node.js it is global, for other environments it may have another name.

Recently, globalThis was added to the language, as a standardized name for a global object, that should be supported across all environments. It’s supported in all major browsers.

We’ll use window here, assuming that our environment is a browser. If your script may run in other environments, it’s better to use globalThis instead.

All properties of the global object can be accessed directly:

alert("Hello");

// is the same as

window.alert("Hello");

In a browser, global functions and variables declared with var (not let/const!) become the property of the global object:

var gVar = 5;

alert(window.gVar); // 5 (became a property of the global object)

The same effect have function declarations (statements with function keyword in the main code flow, not function expressions).

Please don’t rely on that! This behavior exists for compatibility reasons. Modern scripts use [JavaScript modules](https://javascript.info/modules) where such thing doesn’t happen.

If we used let instead, such thing wouldn’t happen:

let gLet = 5;

alert(window.gLet); // undefined (doesn't become a property of the global object)

If a value is so important that you’d like to make it available globally, write it directly as a property:

// make current user information global, to let all scripts access it

window.currentUser = {

name: "John"

};

// somewhere else in code

alert(currentUser.name); // John

// or, if we have a local variable with the name "currentUser"

// get it from window explicitly (safe!)

alert(window.currentUser.name); // John

That said, using global variables is generally discouraged. There should be as few global variables as possible. The code design where a function gets “input” variables and produces certain “outcome” is clearer, less prone to errors and easier to test than if it uses outer or global variables.

## Array

An array is a list of elements that are implemented by a sequence of **consecutive** memory unit

### Create an array and access its element

#### Create an array like a literal or an instance of Array class

* Literal:

var cars = ["Saab", "Volvo", "BMW"];

var cars = [  
  "Saab",  
  "Volvo",  
  "BMW"  
];

* Create an instance of Array class

var cars = new Array("Saab", "Volvo", "BMW");

It’s better to create an array as a literal than an instance of Array class

var points = new Array(40, 100);  // Creates an array with two elements (40 and 100)

but

var points = new Array(40);  // Creates an array with 40 undefined elements !!!!!

#### Set/get elements of array

Access the whole array by using the array’s name

var cars = ["Saab", "Volvo", "BMW"];  
document.getElementById("demo").innerHTML = cars;

Access an element through its index (which starts out by 0):

var cars = ["Saab", "Volvo", "BMW"];  
document.getElementById("demo").innerHTML = cars[0];

cars[0] = "Opel";

var x = cars.length;   // The length property returns the number of elements  
var y = cars.sort();   // The sort() method sorts arrays

New element can also be added to an array using the length property:

var fruits = ["Banana", "Orange", "Apple", "Mango"];  
fruits[fruits.length] = "Lemon";    // adds a new element (Lemon) to fruits

### Array vs Object

Arrays are a special type of objects. The typeof operator in JavaScript returns "object" for arrays.

Arrays use **numbers** to access its "elements" while Objects use **names**. So in the following example, for array: person[0] returns “John”, for object: person.firstName or person[‘firstName’] returns John

var person = ["John", "Doe", 46];

var person = {firstName:"John", lastName:"Doe", age:46};

### push() pop() splice()

#### push() or pop() the last element

The pop() method removes the last element from an array:

var fruits = ["Banana", "Orange", "Apple", "Mango"];  
fruits.pop();              // Removes the last element ("Mango") from fruits

The push() method adds a new element to an array (at the end):

var fruits = ["Banana", "Orange", "Apple", "Mango"];  
fruits.push("Kiwi");       //  Adds a new element ("Kiwi") to fruits

#### Add or remove any element with splice()

The splice() method can be used to add new items to an array:

var fruits = ["Banana", "Orange", "Apple", "Mango"];  
fruits.splice(2, 1, "Lemon", "Kiwi");

Original Array:  
Banana,Orange,Apple,Mango

New Array:  
Banana,Orange,Lemon,Kiwi,Apple,Mango

The first parameter (2) defines the position **where** new elements should be **added** (spliced in).

The second parameter (1) defines **how many** elements should be **removed**.

The rest of the parameters ("Lemon" , "Kiwi") define the new elements to be **added**.

The splice() method returns a new array.

The splice() can be used to remove elements without leaving "holes" in the array:

var fruits = ["Banana", "Orange", "Apple", "Mango"];  
fruits.splice(0, 1);        // Removes the first element of fruits

The first parameter (0) defines the position where new elements should be **added** (spliced in).

The second parameter (1) defines **how many** elements should be **removed**.

The rest of the parameters are omitted. No new elements will be added.

### sort()

The sort() function, by default sorts values as **strings** in the alphabetical order. The reverse() method reverses that order

var fruits = ["Banana", "Orange", "Apple", "Mango"];  
fruits.sort();        // Sorts the elements of fruits so Apple comes before “Banana”

You can provide a compare function to sort your array according to your own order.

The compare function should return a negative, zero, or positive value, depending on the arguments:

function(a, b){return a - b}

When the sort() function compares two values, it sends the values to the compare function, and sorts the values according to the returned (negative, zero, positive) value.

If the result is negative a is sorted before b.

If the result is positive b is sorted before a.

If the result is 0 no changes are done with the sort order of the two values.

For example, to sort an array of numbers ascendingly:

var points = [40, 100, 1, 5, 25, 10];  
points.sort(function(a, b){return a - b});

To sort an array in a random order:

var points = [40, 100, 1, 5, 25, 10];  
points.sort(function(a, b){return 0.5 - Math.random()});

## Operator == vs ===

The difference between == and === is that:

* == **converts** the variable values to the **same** type before performing comparison. This is called [type coercion](https://developer.mozilla.org/en-US/docs/Glossary/Type_coercion).
* === does **not** do any type conversion (coercion) and returns true only **if** both values **and** types are identical for the two variables being compared.

var one = 1;

var one\_again = 1;

var one\_string = "1"; // note: this is string

console.log(one == one\_again); // true

console.log(one === one\_again); // true

console.log(one == one\_string); // true. See below for explanation.

console.log(one === one\_string); // false. See below for explanation.

= and === have their counterparts when it comes to checking for inequality:

* !=: Converts values if variables are different types before checking for inequality
* !==: Checks both type and value for the two variables being compared

var one = 1;

var one\_again = 1;

var one\_string = "1"; // note: this is a string

console.log(one != one\_again); // false

console.log(one != one\_string); // false

console.log(one !== one\_string);// true. Types are different

## typeof returns the type of a variable

The typeof operator returns a string indicating the type of the following operand.

typeof operand

typeof(operand)

Example:

typeof 37 === 'number';

typeof '' === 'string';

typeof Infinity === 'number';

typeof NaN === 'number'; // Despite being "Not-A-Number"

// Objects

typeof {a: 1} === 'object';

// use Array.isArray or Object.prototype.toString.call

// to differentiate regular objects from arrays

typeof [1, 2, 4] === 'object';

typeof new Date() === 'object';

typeof undeclaredVariable === 'undefined';

// Functions

typeof function() {} === 'function';

typeof class C {} === 'function';

typeof Math.sin === 'function';

# Functions and function type

## function expression and function type

Javascript’s function declaration requires “function” keyword, but no return type, no argument types.

Function declaration can be used as a value in an expression, so comes the name function expression.

<script>

    function factorial(n){

        if(n <= 1) return 1;

        else return n\*factorial(n-1);

    }

    // Show the value of factorial, factorial(4)

    console.log('The source code of factorial function is: \n' + factorial);

    console.log('The value of factorial function at 4 is: ' + factorial(4));

    // Now change the value of factorial

    factorial = function negativeOne(){return -1;}

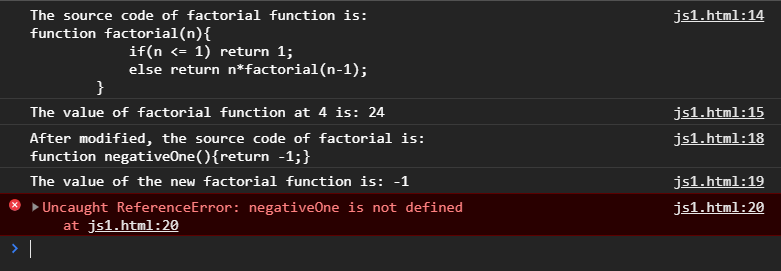
    console.log('After modified, the source code of factorial is: \n' + factorial);

    console.log('The value of the new factorial function is: ' + factorial());

    console.log('The value of negativeOne function is ' + negativeOne()); // Doesn’t compile

</script>

Output:



When you declare a function (but don’t assign it explicitly to any variable), JS automatically declares a variable whose type is ‘function’ (a kind of Object), whose name is the function name, and whose value is the function source code. When you call this function variable, you get the source code of the function. If you add “(argument)” to the function variable, you get the value of function at argument.

When you assign a function expression (i.e. the function declaration) to a variable (so the variable is of ‘function’ type), you cannot call the function through the function name, but only through the variable name so the function name becomes optional. The function name is still needed in the case you want to do recursion, like calculating factorial.

<script>

    var x = function factorial(n){

        if(n <= 1) return 1;

        else return n\*factorial(n-1);

    }

    // Show the value of factorial, factorial(4) through x

    console.log('The source code of factorial function is: \n' + x);

    console.log('The value of factorial function at 4 is: ' + x(4));

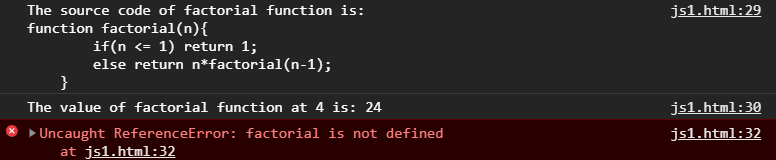
    // Show the value of factorial, factorial(4) through factorial --> error

    console.log('The source code of factorial function is: \n' + factorial); // error

    console.log('The value of factorial function at 4 is: ' + factorial(4)); // error

</script>

Output:



Function expressions are sometimes defined and immediately invoked:

let fourFactorial = (function factorial(n){

    if(n <= 1) return 1;

    else return n\*factorial(n-1);

}(4));

// though 'factorial' name is optional, it's needed here for recursion

Function declaration statements are “hoisted” to the top of the enclosing script, function, or block so that functions defined in this way may be invoked from code that appears before the definition. In contrast, for a function that is defined in a function expression, you can only use the function after the function expression.

## Callback functions

Function expression can be passed as an argument into another function. Firstly, function *arg* is passed into function *Func* as an argument and then while being executed, Func calls arg back, and hence function arg is called a “callback” function.

Example: We’ll write a function ask(question, yes, no) that ask the question and, depending on the user’s answer, call yes() or no():

function ask(question, yes, no) {

if (confirm(question)) yes()

else no();

}

function showOk() {

alert( "You agreed." );

}

function showCancel() {

alert( "You canceled the execution." );

}

// usage: functions showOk, showCancel are passed as arguments to ask

ask("Do you agree?", showOk, showCancel);

The “callback” term means we pass a function and expect it to be “called back” later if necessary. In our case, showOk becomes the callback for “yes” answer, and showCancel for “no” answer.

We can use Function Expressions to write the same function much shorter:

function ask(question, yes, no) {

if (confirm(question)) yes()

else no();

}

ask(

"Do you agree?",

function() { alert("You agreed."); },

function() { alert("You canceled the execution."); }

);

## Arrow functions

Arrow functions are a style of writing functions shorter.

let func = function(arg1, arg2, ...argN) {

return expression;

};

Can be shortened as:

let func = (arg1, arg2, ...argN) => expression

Example:

let sum = (a, b) => a + b;

/\* This arrow function is a shorter form of:

let sum = function(a, b) { return a + b;};

\*/

alert( sum(1, 2) ); // 3

When the function is complex, use { }

let sum = (a, b) => { // the curly brace opens a multiline function

let result = a + b;

return result; // if we use curly braces, then we need an explicit "return"

};

alert( sum(1, 2) ); // 3

# Browser environment

## Window object

Browser window is represented by an object called “window” that provide methods for JS code to control. For example we use “window” object to show the window height:

alert(window.innerHeight); // inner window height

This “window” object is a global object, so everything belongs to it, for example when we define a function it becomes a method of “window”

function sayHi() {

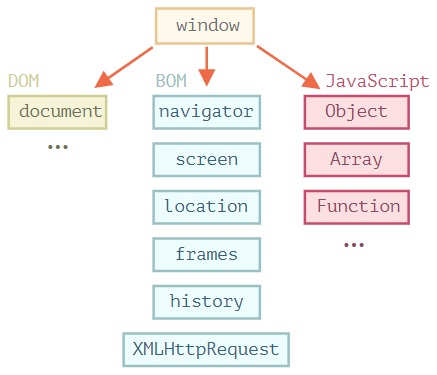
alert("Hello");

}

// global functions are methods of the global object:

window.sayHi();

This window object contains DOM and BOM



### [DOM (Document Object Model)](https://javascript.info/browser-environment" \l "dom-document-object-model)

Document Object Model, or DOM for short, represents all page content as objects that can be modified.

The document object is the main “entry point” to the page. We can change or create anything on the page using it.

For instance:

// change the background color to red

document.body.style.background = "red";

// change it back after 1 second

setTimeout(() => document.body.style.background = "", 1000);

### [BOM (Browser Object Model)](https://javascript.info/browser-environment" \l "bom-browser-object-model)

The Browser Object Model (BOM) represents additional objects provided by the browser (host environment) for working with everything except the document.

For instance:

* The [navigator](https://developer.mozilla.org/en-US/docs/Web/API/Window/navigator) object provides background information about the browser and the operating system. There are many properties, but the two most widely known are: navigator.userAgent – about the current browser, and navigator.platform – about the platform (can help to differ between Windows/Linux/Mac etc).
* The [location](https://developer.mozilla.org/en-US/docs/Web/API/Window/location) object allows us to read the current URL and can redirect the browser to a new one.

Here’s how we can use the location object:

alert(location.href); // shows current URL

if (confirm("Go to Wikipedia?")) {

location.href = "https://wikipedia.org"; // redirect the browser to another URL

}

Functions alert/confirm/prompt are also a part of BOM: they are directly not related to the document, but represent pure browser methods of communicating with the user.

Array vs Object

in web browsers or on V8 engine

Data types:

* String
* Number
* Boolean
* Object
* Function

Array vs

# MISC