

### Introduction

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ECMAScript 6, also known as ECMAScript 2015, is the latest version of the ECMAScript standard. ES6 is a significant update to the language, and the first update to the language since ES5 was standardized in 2009. Implementation of these features in major JavaScript engines is [underway now](#).

See the [ES6 standard](#) for full specification of the ECMAScript 6 language.

ES6 includes the following new features:

- [arrows](#)
- [classes](#)
- [enhanced object literals](#)
- [template strings](#)
- [destructuring](#)
- [default + rest + spread](#)
- [let + const](#)
- [iterators + for..of](#)
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- [map + set + weakmap + weakset](#)
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- [math + number + string + array + object APIs](#)
- [binary and octal literals](#)
- [reflect api](#)
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### ECMAScript 6 Features

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#### Arrows

Arrows are a function shorthand using the `=>` syntax. They are syntactically similar to the related feature in C#, Java 8 and CoffeeScript. They support both statement block bodies as well as expression bodies which return the value of the expression. Unlike functions, arrows share the same lexical `this` as their surrounding code.

```
// Expression bodies
var odds = evens.map(v => v + 1);
var nums = evens.map((v, i) => v + i);
var pairs = evens.map(v => ({even: v, odd: v + 1}));

// Statement bodies
nums.forEach(v => {
  if (v % 5 === 0)
    fives.push(v);
});
```

```
// Lexical this
var bob = {
  _name: "Bob",
  _friends: [],
  printFriends() {
    this._friends.forEach(f =>
      console.log(this._name + " knows " + f));
  }
}
```

More info: [MDN Arrow Functions](#)

## Classes

ES6 classes are a simple sugar over the prototype-based OO pattern. Having a single convenient declarative form makes class patterns easier to use, and encourages interoperability. Classes support prototype-based inheritance, super calls, instance and static methods and constructors.

```
class SkinnedMesh extends THREE.Mesh {
  constructor(geometry, materials) {
    super(geometry, materials);

    this.idMatrix = SkinnedMesh.defaultMatrix();
    this.bones = [];
    this.boneMatrices = [];
    //...
  }
  update(camera) {
    //...
    super.update();
  }
  get boneCount() {
    return this.bones.length;
  }
  set matrixType(matrixType) {
    this.idMatrix = SkinnedMesh[matrixType]();
  }
  static defaultMatrix() {
    return new THREE.Matrix4();
  }
}
```

More info: [MDN Classes](#)

## Enhanced Object Literals

Object literals are extended to support setting the prototype at construction, shorthand for foo: foo assignments, defining methods, making super calls, and computing property names with expressions. Together, these also bring object literals and class declarations closer together, and let object-based design benefit from some of the same conveniences.

```
var obj = {
  // __proto__
  __proto__: theProtoObj,
  // Shorthand for 'handler: handler'
  handler,
  // Methods
  toString() {
    // Super calls
    return "d " + super.toString();
  },
  // Computed (dynamic) property names
```

```
[ 'prop_' + (() => 42)() ]: 42
};
```

More info: [MDN Grammar and types: Object literals](#)

## Template Strings

Template strings provide syntactic sugar for constructing strings. This is similar to string interpolation features in Perl, Python and more. Optionally, a tag can be added to allow the string construction to be customized, avoiding injection attacks or constructing higher level data structures from string contents.

```
// Basic literal string creation
`In JavaScript '\n' is a line-feed.`

// Multiline strings
`In JavaScript this is
not legal.`

// String interpolation
var name = "Bob", time = "today";
`Hello ${name}, how are you ${time}?`

// Construct an HTTP request prefix is used to interpret the replacements and
construction
POST`http://foo.org/bar?a=${a}&b=${b}
Content-Type: application/json
X-Credentials: ${credentials}
{ "foo": ${foo},
  "bar": ${bar}}`(myOnReadyStateChangeHandler);
```

More info: [MDN Template Strings](#)

## Destructuring

Destructuring allows binding using pattern matching, with support for matching arrays and objects. Destructuring is fail-soft, similar to standard object lookup `foo["bar"]`, producing undefined values when not found.

```
// list matching
var [a, , b] = [1,2,3];

// object matching
var { op: a, lhs: { op: b }, rhs: c }
    = getASTNode()

// object matching shorthand
// binds `op`, `lhs` and `rhs` in scope
var {op, lhs, rhs} = getASTNode()

// Can be used in parameter position
function g({name: x}) {
  console.log(x);
}
g({name: 5})

// Fail-soft destructuring
var [a] = [];
a === undefined;

// Fail-soft destructuring with defaults
var [a = 1] = [];
a === 1;
```

More info: [MDN Destructuring assignment](#)

## Default + Rest + Spread

Callee-evaluated default parameter values. Turn an array into consecutive arguments in a function call. Bind trailing parameters to an array. Rest replaces the need for arguments and addresses common cases more directly.

```
function f(x, y=12) {  
  // y is 12 if not passed (or passed as undefined)  
  return x + y;  
}  
f(3) == 15  
  
function f(x, ...y) {  
  // y is an Array  
  return x * y.length;  
}  
f(3, "hello", true) == 6  
  
function f(x, y, z) {  
  return x + y + z;  
}  
// Pass each elem of array as argument  
f(...[1,2,3]) == 6
```

More MDN info: [Default parameters](#), [Rest parameters](#), [Spread Operator](#)

## Let + Const

Block-scoped binding constructs. let is the new var. const is single-assignment. Static restrictions prevent use before assignment.

```
function f() {  
  {  
    let x;  
    {  
      // okay, block scoped name  
      const x = "sneaky";  
      // error, const  
      x = "foo";  
    }  
    // error, already declared in block  
    let x = "inner";  
  }  
}
```

More MDN info: [let statement](#), [const statement](#)

## Iterators + For..Of

Iterator objects enable custom iteration like CLR IEnumerable or Java Iterable. Generalize for...in to custom iterator-based iteration with for...of. Don't require realizing an array, enabling lazy design patterns like LINQ.

```
let fibonacci = {  
  [Symbol.iterator]() {  
    let pre = 0, cur = 1;  
    return {  
      next() {  
        [pre, cur] = [cur, pre + cur];  
        return { done: false, value: cur }  
      }  
    }  
  }  
}
```

```

}

for (var n of fibonacci) {
  // truncate the sequence at 1000
  if (n > 1000)
    break;
  console.log(n);
}

```

Iteration is based on these duck-typed interfaces (using [TypeScript](#) type syntax for exposition only):

```

interface IteratorResult {
  done: boolean;
  value: any;
}
interface Iterator {
  next(): IteratorResult;
}
interface Iterable {
  [Symbol.iterator](): Iterator
}

```

More info: [MDN for...of](#)

## Generators

Generators simplify iterator-authoring using `function*` and `yield`. A function declared as `function*` returns a Generator instance. Generators are subtypes of iterators which include additional `next` and `throw`. These enable values to flow back into the generator, so `yield` is an expression form which returns a value (or throws).

Note: Can also be used to enable 'await'-like async programming, see also ES7 `await` proposal.

```

var fibonacci = {
  [Symbol.iterator]: function*() {
    var pre = 0, cur = 1;
    for (;;) {
      var temp = pre;
      pre = cur;
      cur += temp;
      yield cur;
    }
  }
}

for (var n of fibonacci) {
  // truncate the sequence at 1000
  if (n > 1000)
    break;
  console.log(n);
}

```

The generator interface is (using [TypeScript](#) type syntax for exposition only):

```

interface Generator extends Iterator {
  next(value?: any): IteratorResult;
  throw(exception: any);
}

```

More info: [MDN Iteration protocols](#)

## Unicode

Non-breaking additions to support full Unicode, including new Unicode literal form in strings and new RegExp u mode to handle code points, as well as new APIs to process strings at the 21bit code points level. These additions support building global apps in JavaScript.

```
// same as ES5.1
"吉".length == 2

// new RegExp behaviour, opt-in 'u'
"吉".match(/./u)[0].length == 2

// new form
"\u{20BB7}"=="吉"=="\uD842\uDFB7"

// new String ops
"吉".codePointAt(0) == 0x20BB7

// for-of iterates code points
for(var c of "吉") {
  console.log(c);
}
```

More info: [MDN RegExp.prototype.unicode](https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/RegExp.prototype/unicode)

## Modules

Language-level support for modules for component definition. Codifies patterns from popular JavaScript module loaders (AMD, CommonJS). Runtime behaviour defined by a host-defined default loader. Implicitly async model – no code executes until requested modules are available and processed.

```
// lib/math.js
export function sum(x, y) {
  return x + y;
}
export var pi = 3.141593;

// app.js
import * as math from "lib/math";
alert("2π = " + math.sum(math.pi, math.pi));

// otherApp.js
import {sum, pi} from "lib/math";
alert("2π = " + sum(pi, pi));
```

Some additional features include export default and export \*:

```
// lib/mathplusplus.js
export * from "lib/math";
export var e = 2.71828182846;
export default function(x) {
  return Math.log(x);
}

// app.js
import ln, {pi, e} from "lib/mathplusplus";
alert("2π = " + ln(e)*pi*2);
```

More MDN info: [import statement](https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Statements/import), [export statement](https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Statements/export)

## Module Loaders

Module loaders support:

- Dynamic loading

- State isolation
- Global namespace isolation
- Compilation hooks
- Nested virtualization

The default module loader can be configured, and new loaders can be constructed to evaluate and load code in isolated or constrained contexts.

```
// Dynamic loading - 'System' is default loader
System.import('lib/math').then(function(m) {
  alert("2π = " + m.sum(m.pi, m.pi));
});

// Create execution sandboxes - new Loaders
var loader = new Loader({
  global: fixup(window) // replace 'console.log'
});
loader.eval("console.log('hello world!');");

// Directly manipulate module cache
System.get('jquery');
System.set('jquery', Module({$: $})); // WARNING: not yet finalized
```

## Map + Set + WeakMap + WeakSet

Efficient data structures for common algorithms. WeakMaps provides leak-free object-key'd side tables.

```
// Sets
var s = new Set();
s.add("hello").add("goodbye").add("hello");
s.size === 2;
s.has("hello") === true;

// Maps
var m = new Map();
m.set("hello", 42);
m.set(s, 34);
m.get(s) === 34;

// Weak Maps
var wm = new WeakMap();
wm.set(s, { extra: 42 });
wm.size === undefined

// Weak Sets
var ws = new WeakSet();
ws.add({ data: 42 });
// Because the added object has no other references, it will not be held in the set
```

More MDN info: [Map](#), [Set](#), [WeakMap](#), [WeakSet](#)

## Proxies

Proxies enable creation of objects with the full range of behaviors available to host objects. Can be used for interception, object virtualization, logging/profiling, etc.

```
// Proxying a normal object
var target = {};
var handler = {
```

```

    get: function (receiver, name) {
        return `Hello, ${name}!`;
    }
};

var p = new Proxy(target, handler);
p.world === 'Hello, world!';

// Proxying a function object
var target = function () { return 'I am the target'; };
var handler = {
    apply: function (receiver, ...args) {
        return 'I am the proxy';
    }
};

var p = new Proxy(target, handler);
p() === 'I am the proxy';

```

There are traps available for all of the runtime-level meta-operations:

```

var handler =
{
    get:...,
    set:...,
    has:...,
    deleteProperty:...,
    apply:...,
    construct:...,
    getOwnPropertyDescriptor:...,
    defineProperty:...,
    getPrototypeOf:...,
    setPrototypeOf:...,
    enumerate:...,
    ownKeys:...,
    preventExtensions:...,
    isExtensible:...
}

```

More info: [MDN Proxy](#)

## Symbols

Symbols enable access control for object state. Symbols allow properties to be keyed by either string (as in ES5) or symbol. Symbols are a new primitive type.

Optional description parameter used in debugging - but is not part of identity. Symbols are unique (like gensym), but not private since they are exposed via reflection features like `Object.getOwnPropertySymbols`.

```

var MyClass = (function() {

    // module scoped symbol
    var key = Symbol("key");

    function MyClass(privateData) {
        this[key] = privateData;
    }

    MyClass.prototype = {
        doStuff: function() {
            ... this[key] ...
        }
    };
});

```



```

    return MyClass;
  })();

var c = new MyClass("hello")
c["key"] === undefined

```

More info: [MDN Symbol](#)

## Subclassable Built-ins

In ES6, built-ins like Array, Date and DOM Elements can be subclassed.

Object construction for a function named Ctor now uses two-phases (both virtually dispatched):

- Call Ctor[[@@create](#)] to allocate the object, installing any special behavior
- Invoke constructor on new instance to initialize

The known [@@create](#) symbol is available via `Symbol.create`. Built-ins now expose their [@@create](#) explicitly.

```

// Pseudo-code of Array
class Array {
  constructor(...args) { /* ... */ }
  static [Symbol.create]() {
    // Install special [[DefineOwnProperty]]
    // to magically update 'length'
  }
}

// User code of Array subclass
class MyArray extends Array {
  constructor(...args) { super(...args); }
}

// Two-phase 'new':
// 1) Call @@create to allocate object
// 2) Invoke constructor on new instance
var arr = new MyArray();
arr[1] = 12;
arr.length == 2

```

## Math + Number + String + Array + Object APIs

Many new library additions, including core Math libraries, Array conversion helpers, String helpers, and `Object.assign` for copying.

```

Number.EPSILON
Number.isInteger(Infinity) // false
Number.isNaN("NaN") // false

Math.acosh(3) // 1.762747174039086
Math.hypot(3, 4) // 5
Math.imul(Math.pow(2, 32) - 1, Math.pow(2, 32) - 2) // 2

"abcde".includes("cd") // true
"abc".repeat(3) // "abcabcabc"

Array.from(document.querySelectorAll('*')) // Returns a real Array
Array.of(1, 2, 3) // Similar to new Array(...), but without special one-arg
behavior
[0, 0, 0].fill(7, 1) // [0,7,7]
[1, 2, 3].find(x => x == 3) // 3
[1, 2, 3].findIndex(x => x == 2) // 1

```

```
[1, 2, 3, 4, 5].copyWithin(3, 0) // [1, 2, 3, 1, 2]
["a", "b", "c"].entries() // iterator [0, "a"], [1, "b"], [2, "c"]
["a", "b", "c"].keys() // iterator 0, 1, 2
["a", "b", "c"].values() // iterator "a", "b", "c"

Object.assign(Point, { origin: new Point(0,0) })
```

More MDN info: [Number](#), [Math](#), [Array.from](#), [Array.of](#), [Array.prototype.copyWithin](#), [Object.assign](#)

## Binary and Octal Literals

Two new numeric literal forms are added for binary (b) and octal (o).

```
0b111110111 === 503 // true
0o767 === 503 // true
```

## Promises

Promises are a library for asynchronous programming. Promises are a first class representation of a value that may be made available in the future. Promises are used in many existing JavaScript libraries.

```
function timeout(duration = 0) {
  return new Promise((resolve, reject) => {
    setTimeout(resolve, duration);
  })
}

var p = timeout(1000).then(() => {
  return timeout(2000);
}).then(() => {
  throw new Error("hmm");
}).catch(err => {
  return Promise.all([timeout(100), timeout(200)]);
})
```

More info: [MDN Promise](#)

## Reflect API

Full reflection API exposing the runtime-level meta-operations on objects. This is effectively the inverse of the Proxy API, and allows making calls corresponding to the same meta-operations as the proxy traps. Especially useful for implementing proxies.

```
// No sample ye
```

More info: [MDN Reflect](#)

## Tail Calls

Calls in tail-position are guaranteed to not grow the stack unboundedly. Makes recursive algorithms safe in the face of unbounded inputs.

```
function factorial(n, acc = 1) {
  'use strict';
  if (n <= 1) return acc;
  return factorial(n - 1, n * acc);
}

// Stack overflow in most implementations today,
// but safe on arbitrary inputs in ES6
factorial(100000)
```