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JavaScript Classes and Modules

“The” language of the Web

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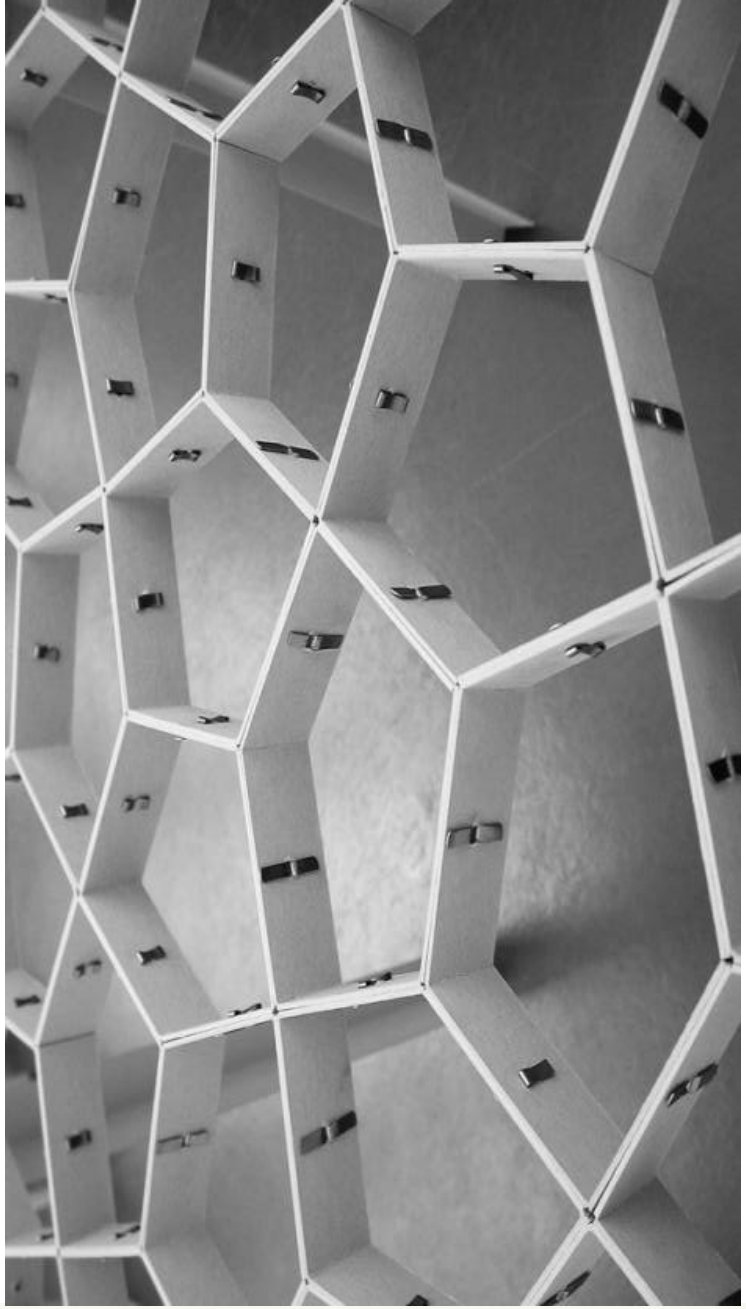

JavaScript: The Definitive Guide, 7th Edition

- Chapter 9. Classes

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You Don't Know JS: this & Object Prototypes

- Chapter 5: Prototypes

Modular JS programming

PROTOTYPES

A Prototype-based Language

- JavaScript is an object-based language based on prototypes, rather than being class-based
  - classes exist but they are "syntactical sugar", primarily
- Every JS object has a hidden (internal) property `[[Prototype]]` that points to a second object associated with it (or it is null)
  - Read with `Object.getPrototypeOf(object)`
  - Change with `Object.setPrototypeOf(object, prototype)`
  - Usually also accessible with `.__proto__` (double underscores) – but *deprecated!*

A Prototype-based Language

- This second object is known as an *object prototype*
- Such object also has a [[Prototype]] property, that links to a 3rd object
  - …until the [[Prototype]] is null
- Usually, only `Object` (top-level object) points to a null prototype

- Classes and constructor functions also have a `.prototype` attribute, that points to prototype objects for objects created by them
  - Do not confuse `.prototype` and `[[Prototype]]`

Prototype Chaining

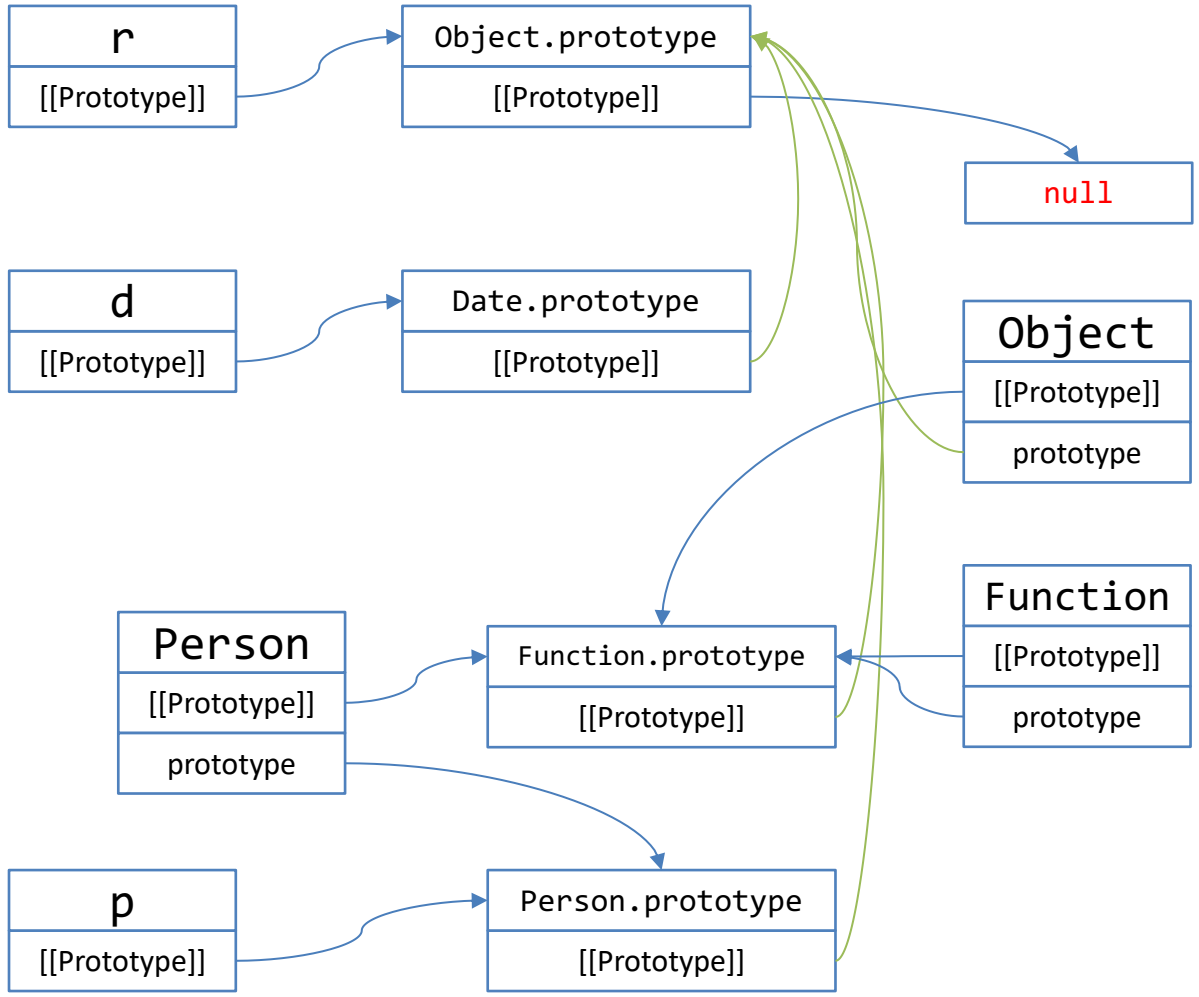
```
function Person(name) {
  this.name = name;
}

const p = new Person('Fulvio');

const d = new Date();

const r = {min: 0, max: 30};

console.log(p); // Person {name: "Fulvio"}
console.log(d); // Thu Apr 09 2020 21:06:29
GMT+0200 (Central European Summer Time)
console.log(r); // Object {min: 0, max: 30}
```



Object.prototype

- Prototype chains usually end at `Object.prototype`
  - Its `[[Prototype]]` is `null`
- `Object.prototype` defines many properties and methods that are common to all JS objects
  - .toString(), .valueOf(), .getPrototypeOf(), .setPrototypeOf(), .toSource(), .isPrototypeOf(), .hasOwnProperty(), …
- All objects created by object literals (i.e., `{}`) have the *same* prototype object: `Object.prototype`

Accessing “Inherited” Properties

- Prototypes are used in accessing object properties
  - Not “real” inheritance
- Reading properties
  - If the property is defined on the object, use it
  - If it is not defined, JS will search on the [[Prototype]] chain
    - If it is found somewhere, its value is used
    - If ‘null’ is reached, then return undefined
- Writing properties
  - Does not follow the prototype chain (*)
  - If it is not defined on the object, a new one is created
    - and may shadow a same-name property on the prototype chain

(*) not really true: read-only inherit properties and setters of inherited properties behave differently

Class-based vs. Prototype-based Languages

Category	Class-based (Java)	Prototype-based (JavaScript)
Class vs. Instance	Class and instance are distinct entities.	All objects can inherit from another object.
Definition	Define a class with a class definition; instantiate a class with constructor methods.	Define and create a set of objects with constructor functions.
Creation of new object	Create a single object with the `new` operator.	Same.
Construction of object hierarchy	Construct an object hierarchy by using class definitions to define subclasses of existing classes.	Construct an object hierarchy by assigning an object as the prototype associated with a constructor function.
Inheritance model	Inherit properties by following the class chain.	Inherit properties by following the prototype chain.
Extension of properties	Class definition specifies *all* properties of all instances of a class. Cannot add properties dynamically at run time.	Constructor function or prototype specifies an *initial set* of properties. Can add or remove properties dynamically to individual objects or to the entire set of objects.

source: https://developer.mozilla.org/en-US/docs/Web/JavaScript/Guide/Details_of_the_Object_Model

https://www.thecodeship.com/web-development/methods-within-constructor-vs-prototype-in-javascript/

Where To Define Method Functions?

In the constructor function body

- Slower to create: function is re-declared for every new instance
- Faster to call: local property
- Memory per each instance
- May be redefined on a single instance
- Can access local variables (via closure)

As a prototype property

- Faster to create: declared only once
- Slower to call: must go through prototype
- Uses less memory
- Always identical for all instances
- Cannot access local variables

```
function Person(name, age, game) {
  this.play = function() {
    console.log(`${this.game}`);
  };
}
```

```
Person.prototype.showAge = function() {
  console.log(`${this.age} years old`);
};
```

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CLASSES

Classes

- Classes are primarily *syntactical* sugar over JavaScript's existing prototype-based inheritance
  - included from ES6
- They are special functions, based on the `class` keyword
- Two ways to define a class:
  - **class declaration**
  - **class expression**
- An object can be instantiated with the `new` keyword

Class Declaration

- Classic way to define a class:
  - `class` + chosen name of the class
- Class declarations are not hoisted
  - you cannot instantiate a class before declaring it
    - you should not, in any case!

```
class Rectangle {
  constructor(height, width) {
    this.height = height;
    this.width = width;
  }
}
```

Class Expression

- Another way to define a class, with two variants:
  - *named*
  - *unnamed*
- The name given to a (named) class expression is local to the class body
  - and accessed through the class' name property
  - it is "myRectangle" and "Rectangle" for the example
- Like class declarations, they are not hoisted

```
// named
let Rectangle = class myRectangle {
  constructor(height, width) {
    this.height = height;
    this.width = width;
  }
};

// unnamed
let Rectangle = class {
  constructor(height, width) {
    this.height = height;
    this.width = width;
  }
};
```

Class Body

- The class body is always executed in **strict mode**
- Each class can have only one `constructor()`
  - a constructor can use the `super` keyword to call the constructor of the super class
- Classes can have
  - prototype methods
  - static methods

```
class Rectangle {
  constructor(height, width) {
    this.height = height;
    this.width = width;
  }
}
```

Prototype Methods

- Several types of prototype methods exist
- The syntax for a method is:
  - `methodName() { /* method body */ }`
  - it adds a property named `methodName` to the class and sets the value of that property to the specified function
  - you use this with *objects*, too

```
class Rectangle {
  constructor(height, width) {
    this.height = height;
    this.width = width;
  }
  // Method
  calcArea() {
    return this.height * this.width;
  }
}
const square = new Rectangle(10, 10);
console.log(square.calcArea());
```

Prototype Methods: Getters and Setters

- JavaScript defines two methods to create a *pseudo-property*
- **Getters** allow access to a property that returns a dynamically computed or internal value
  - `get` propname()
- **Setters** are used to execute a function whenever a specified property is attempted to be changed
  - `set` propname()

```
class Rectangle {
  constructor(height, width) {
    this.height = height;
    this.width = width;
  }
  // Getter
  get perimeter() {
    return this.calcPerimeter();
  }
  // Setter
  set perimeter(perimeter) {
    this.height = perimeter/2 - this.width;
  }
  // Method
  calcPerimeter() {
    return 2*(this.height + this.width);
  }
}
const square = new Rectangle(10, 10);
square.perimeter = 100;
console.log(square.perimeter);
```

Static Methods

- The `static` keyword defines a static method for a class
- Static methods are called without instantiating their class and cannot be called through a class instance
- The ‘this’ keyword may **not** be used inside static methods

```
class Rectangle {
  constructor(height, width) {
    this.height = height;
    this.width = width;
  }
  // Static method
  static isWider(a, b) {
    return (a.width > b.width)? a: b;
  }
}
const s = new Rectangle(10, 15);
const r = new Rectangle(20, 30);
console.log(Rectangle.isWider(s, r));
```

Subclassing and Super Class Calls

- The `extends` keyword is used to create a class as a child of another class
  - it works with "super classes" defined as construction functions, too
- The `super` keyword is used to call corresponding methods of super class
  - *not* only the constructor!
  - not *only* from the constructor!

```
class Person {
  constructor(first, last, age, gender, interests) {
    this.name = { 'first': first, 'last' : last };
    this.age = age;
    this.gender = gender;
    this.interests = interests;
  }
  sleep() {
    console.log(`${this.name.first} is sleeping.`)
  }
  play() {
    console.log(`${this.name.first} is having fun.`)
  }
}

class Student extends Person {
  constructor(first, last, age, gender, interests, id) {
    super(first, last, age, gender, interests);
    this.id = id;
  }
}
```

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Chapter 10. Modules

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- Web technology for developers » JavaScript » JavaScript Guide » JavaScript Modules

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MODULES

Modules

- Mechanisms for splitting JavaScript programs into separate files that can be imported when needed
- Encapsulate or hide private implementation details and keep the global namespace tidy so that modules can not accidentally modify the variables, functions and classes defined by other modules
- 3 kinds of modules ⟹

1. *Do-It-Yourself* (with classes, objects, IIFE and closures)
2. **ES6 modules** (using `export` and `import`)
    1. ECMA Standard
    2. Supported by recent browsers
    3. Supported by Node (v13+)
3. Node.js modules (using `require()`) – called **CommonJS**
    1. Based on closures
    2. Never standardized by ECMA, but the normal practice with Node

ES6 Modules

ES6

- A module is a JavaScript file that **exports** one or more values (objects, functions or variables), using the `export` keyword
  - each module is a piece of code that is executed once it is loaded
- Any other JavaScript module can **import** the functionality offered by another module by importing it, with the `import` keyword
- Imports and exports must be at the *top level*
- Two main kinds of exports:
  - **named** exports (several per module)
  - **default** exports (one per module)

Default Export

ES6

- Modules that only export **single values**
  - one per module
  - You are exporting a values, but not the name of the resource
- Syntax
  - `export default <value>`

```
export default str =>
str.toUpperCase();

// OTHER examples
export default {x: 5, y: 6};

export default "name";

function grades(student) {...};
export default grades;
```

Named Exports

ES6

- Modules that export **one or more values**
  - several per module
  - Exports also the names
- Syntax
  - `export <value>`
  - `export {<value>, <...>}`

```
export const name = 'Luigi';

function grades(student) {...};
export grades;

const name = 'Luigi';
const anotherName = 'Fulvio';
export { name, anotherName }
// we can also rename them...
// export {name, anotherName as
teacher}
```

Imports

ES6

- To import something exported by another module
- Syntax
  - `import package from 'module-name'`
- Imports are:
  - hoisted
  - read-only views on exports

Import From a **Default** Export

ES6

```
--- module1.js ---
export default str =>
str.toUpperCase();
```

```
--- module2.js ---
import toUpperCase from './module1.js';
// you choose the name!

// another example
import uppercase from
'/home/app/module1.js';

// usage of the imported function
uppercase('test');
```

Import From a Named Export

ES6

```
--- module1.js ---
const name = 'Luigi';
const anotherName = 'Fulvio';

export { name, anotherName };
```

```
--- module2.js ---
import { name, anotherName } from
'./module1.js';

// you can rename imported values, if
you want
import { name as first, anotherName as
second} from './module1.js';

// usage
console.log(first);
```

Other Imports Options

ES6

- You can import everything a module exports
  - `import * from 'module'`
- You can import a few of the exports (e.g., if `exports {a, b, c}`):
  - `import {a} from 'module'`
- You can import the default export alongside with any named exports:
  - `import default, { name } from 'module'`

ES6 Modules In The Browser

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

https://v8.dev/features/modules

ES6

- File extension
  - Preferred: `.mjs` (ensure the server sets `Content-Type: text/javascript`)
  - Also accepted: `.js`
- Load in HTML
  - `<script type="module" src="main.js"></script>`
  - Only load the “main” modules, others will be loaded by `import` statements
  - Only files loaded with `type="module"` may use `import` and `export`
  - Modules are automatically loaded in `defer` mode
  - Note: locally loading modules (`file:///`) does not work due to CORS

ES6 Modules In Node.js

ES6

- Node.js started to support ES6 modules only recently
- From Node.js v14 (LTS)
  - Enabled by default
  - Must use a file extension of .mjs *or* specify `"type": "module"` in package.json
  - https://nodejs.org/docs/latest-v14.x/api/esm.html#esm_enabling
- **Beware**: not all Node.js modules are provided as ES6 modules

CommonJS Modules

CJS

- The standard module format in Node.js
- Uses the `.js` or `.cjs` extension
- Not natively supported by browsers
  - Unless you use libraries such as RequireJS (https://requirejs.org/)
- It is basically a wrapper around your module code

```
(function(exports, require, module, __filename, __dirname) {
// Module code actually lives in here
});
```

https://nodejs.org/docs/latest-v14.x/api/modules.html

CommonJS Imports

CJS

- To import something exported by another module
- `const package = require('module-name')`
  - Looked up in node_modules
- `const myLocalModule = require('./path/myLocalModule');`
  - Looked up in a relative path from __dirname or $cwd

CommonJS Exports

CJS

- Assign your exported variables by creating new properties in the object `module.exports` (shortcut: `exports`)
- Examples:
  - `exports.area = (r) => Math.PI * r ** 2;`
  -
```
module.exports = class Square {
  constructor(width) {
    this.width = width;
  }
  area() {
    return this.width ** 2;
  }
};
```

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