Array methods

Arrays provide a lot of methods. To make things easier, in this chapter they are split into groups.

Add/remove items

We already know methods that add and remove items from the beginning or the end:

- `arr.push(...items)` – adds items to the end,
- `arr.pop()` – extracts an item from the end,
- `arr.shift()` – extracts an item from the beginning,
- `arr.unshift(...items)` – adds items to the beginning.

Here are few others.

splice

How to delete an element from the array?

The arrays are objects, so we can try to use `delete`:

```
let arr = ["I", "go", "home"];

delete arr[1]; // remove "go"

alert( arr[1] ); // undefined

// now arr = ["I",  , "home"];
alert( arr.length ); // 3
```

The element was removed, but the array still has 3 elements, we can see that `arr.length == 3`.

That's natural, because `delete obj.key` removes a value by the `key`. It's all it does. Fine for objects. But for arrays we usually want the rest of elements to shift and occupy the freed place. We expect to have a shorter array now.

So, special methods should be used.

The arr.splice(str) method is a swiss army knife for arrays. It can do everything: add, remove and insert elements.

The syntax is:

```
arr.splice(index[, deleteCount, elem1, ..., elemN])
```

It starts from the position `index`: removes `deleteCount` elements and then inserts `elem1, ..., elemN` at their place. Returns the array of removed elements.

This method is easy to grasp by examples.

Let's start with the deletion:

```
let arr = ["I", "study", "JavaScript"];

arr.splice(1, 1); // from index 1 remove 1 element

alert( arr ); // ["I", "JavaScript"]
```

Easy, right? Starting from the index `1` it removed `1` element.

In the next example we remove 3 elements and replace them with the other two:

```
let arr = ["I", "study", "JavaScript", "right", "now"];

// remove 3 first elements and replace them with another
```

```
arr.splice(0, 3, "Let's", "dance");

alert( arr ) // now ["Let's", "dance", "right", "now"]
```

Here we can see that `splice` returns the array of removed elements:

```
let arr = ["I", "study", "JavaScript", "right", "now"];

// remove 2 first elements
let removed = arr.splice(0, 2);

alert( removed ); // "I", "study" <-- array of removed elements
```

The `splice` method is also able to insert the elements without any removals. For that we need to set `deleteCount` to `0`:

```
let arr = ["I", "study", "JavaScript"];

// from index 2
// delete 0
// then insert "complex" and "language"
arr.splice(2, 0, "complex", "language");

alert( arr ); // "I", "study", "complex", "language", "JavaScript"
```

Negative indexes allowed

Here and in other array methods, negative indexes are allowed. They specify the position from the end of the array, like here:

```
let arr = [1, 2, 5];

// from index -1 (one step from the end)
// delete 0 elements,
// then insert 3 and 4
arr.splice(-1, 0, 3, 4);

alert( arr ); // 1,2,3,4,5
```

slice

The method arr.slice is much simpler than similar-looking `arr.splice`.

The syntax is:

```
arr.slice(start, end)
```

It returns a new array containing all items from index `"start"` to `"end"` (not including `"end"`). Both `start` and `end` can be negative, in that case position from array end is assumed.

It works like `str.slice`, but makes subarrays instead of substrings.

For instance:

```
let str = "test";
let arr = ["t", "e", "s", "t"];

alert( str.slice(1, 3) ); // es
alert( arr.slice(1, 3) ); // e,s

alert( str.slice(-2) ); // st
alert( arr.slice(-2) ); // s,t
```

concat

The method arr.concat joins the array with other arrays and/or items.

The syntax is:

```
arr.concat(arg1, arg2...)
```

It accepts any number of arguments – either arrays or values.

The result is a new array containing items from `arr`, then `arg1`, `arg2` etc.

If an argument is an array or has `Symbol.isConcatSpreadable` property, then all its elements are copied. Otherwise, the argument itself is copied.

For instance:

```
let arr = [1, 2];

// merge arr with [3,4]
alert( arr.concat([3, 4])); // 1,2,3,4

// merge arr with [3,4] and [5,6]
alert( arr.concat([3, 4], [5, 6])); // 1,2,3,4,5,6

// merge arr with [3,4], then add values 5 and 6
alert( arr.concat([3, 4], 5, 6)); // 1,2,3,4,5,6
```

Normally, it only copies elements from arrays ("spreads" them). Other objects, even if they look like arrays, added as a whole:

```
let arr = [1, 2];

let arrayLike = {
  0: "something",
  length: 1
};

alert( arr.concat(arrayLike) ); // 1,2,[object Object]
//[1, 2, arrayLike]
```

...But if an array-like object has `Symbol.isConcatSpreadable` property, then its elements are added instead:

```
let arr = [1, 2];

let arrayLike = {
  0: "something",
  1: "else",
  [Symbol.isConcatSpreadable]: true,
  length: 2
};

alert( arr.concat(arrayLike) ); // 1,2,something,else
```

Iterate: forEach

The arr.forEach method allows to run a function for every element of the array.

The syntax:

```
arr.forEach(function(item, index, array) {
  // ... do something with item
});
```

For instance, this shows each element of the array:

```
// for each element call alert
["Bilbo", "Gandalf", "Nazgul"].forEach(alert);
```

And this code is more elaborate about their positions in the target array:

```
["Bilbo", "Gandalf", "Nazgul"].forEach((item, index, array) => {
  alert(`${item} is at index ${index} in ${array}`);
});
```

The result of the function (if it returns any) is thrown away and ignored.

Searching in array

These are methods to search for something in an array.

indexOf/lastIndexOf and includes

The methods arr.indexOf, arr.lastIndexOf and arr.includes have the same syntax and do essentially the same as their string counterparts, but operate on items instead of characters:

- `arr.indexOf(item, from)` looks for `item` starting from index `from`, and returns the index where it was found, otherwise `-1`.
- `arr.lastIndexOf(item, from)` – same, but looks from right to left.
- `arr.includes(item, from)` – looks for `item` starting from index `from`, returns `true` if found.

For instance:

```
let arr = [1, 0, false];

alert( arr.indexOf(0) ); // 1
alert( arr.indexOf(false) ); // 2
alert( arr.indexOf(null) ); // -1

alert( arr.includes(1) ); // true
```

Note that the methods use `===` comparison. So, if we look for `false`, it finds exactly `false` and not the zero.

If we want to check for inclusion, and don't want to know the exact index, then `arr.includes` is preferred.

Also, a very minor difference of `includes` is that it correctly handles `NaN`, unlike `indexOf/lastIndexOf`:

```
const arr = [NaN];
alert( arr.indexOf(NaN) ); // -1 (should be 0, but === equality doesn't work for NaN)
alert( arr.includes(NaN) );// true (correct)
```

find and findIndex

Imagine we have an array of objects. How do we find an object with the specific condition?

Here the arr.find method comes in handy.

The syntax is:

```
let result = arr.find(function(item, index, array) {
  // if true is returned, item is returned and iteration is stopped
  // for falsy scenario returns undefined
});
```

The function is called repetitively for each element of the array:

- `item` is the element.
- `index` is its index.
- `array` is the array itself.

If it returns `true`, the search is stopped, the `item` is returned. If nothing found, `undefined` is returned.

For example, we have an array of users, each with the fields `id` and `name`. Let's find the one with `id == 1`:

```
let users = [
  {id: 1, name: "John"},
  {id: 2, name: "Pete"},
  {id: 3, name: "Mary"}
];

let user = users.find(item => item.id == 1);

alert(user.name); // John
```

In real life arrays of objects is a common thing, so the `find` method is very useful.

Note that in the example we provide to `find` the function `item => item.id == 1` with one argument. Other arguments of this function are rarely used.

The arr.findIndex method is essentially the same, but it returns the index where the element was found instead of the element itself and `-1` is returned when nothing is found.

filter

The `find` method looks for a single (first) element that makes the function return `true`.

If there may be many, we can use arr.filter(fn).

The syntax is similar to `find`, but filter continues to iterate for all array elements even if `true` is already returned:

```
let results = arr.filter(function(item, index, array) {
  // if true item is pushed to results and iteration continues
  // returns empty array for complete falsy scenario
});
```

For instance:

```
let users = [
  {id: 1, name: "John"},
  {id: 2, name: "Pete"},
  {id: 3, name: "Mary"}
];

// returns array of the first two users
let someUsers = users.filter(item => item.id < 3);

alert(someUsers.length); // 2
```

Transform an array

This section is about the methods transforming or reordering the array.

map

The arr.map method is one of the most useful and often used.

The syntax is:

```
let result = arr.map(function(item, index, array) {
  // returns the new value instead of item
})
```

It calls the function for each element of the array and returns the array of results.

For instance, here we transform each element into its length:

```
let lengths = ["Bilbo", "Gandalf", "Nazgul"].map(item => item.length);
alert(lengths); // 5,7,6
```

sort(fn)

The method arr.sort sorts the array *in place*.

For instance:

```
let arr = [ 1, 2, 15 ];

// the method reorders the content of arr (and returns it)
arr.sort();

alert( arr );  // 1, 15, 2
```

Did you notice anything strange in the outcome?

The order became `1, 15, 2`. Incorrect. But why?

The items are sorted as strings by default.

Literally, all elements are converted to strings and then compared. So, the lexicographic ordering is applied and indeed `"2" > "15"`.

To use our own sorting order, we need to supply a function of two arguments as the argument of `arr.sort()`.

The function should work like this:

```
function compare(a, b) {
  if (a > b) return 1;
  if (a == b) return 0;
  if (a < b) return -1;
}
```

For instance:

```
function compareNumeric(a, b) {
  if (a > b) return 1;
  if (a == b) return 0;
  if (a < b) return -1;
}

let arr = [ 1, 2, 15 ];

arr.sort(compareNumeric);

alert(arr);  // 1, 2, 15
```

Now it works as intended.

Let's step aside and think what's happening. The `arr` can be array of anything, right? It may contain numbers or strings or html elements or whatever. We have a set of *something*. To sort it, we need an *ordering function* that knows how to compare its elements. The default is a string order.

The `arr.sort(fn)` method has a built-in implementation of sorting algorithm. We don't need to care how it exactly works (an optimized quicksort most of the time). It will walk the array, compare its elements using the provided function and reorder them, all we need is to provide the `fn` which does the comparison.

By the way, if we ever want to know which elements are compared – nothing prevents from alerting them:

```
[1, -2, 15, 2, 0, 8].sort(function(a, b) {
  alert( a + " <> " + b );
});
```

The algorithm may compare an element multiple times in the process, but it tries to make as few comparisons as possible.

A comparison function may return any number

Actually, a comparison function is only required to return a positive number to say "greater" and a negative number to say "less".

That allows to write shorter functions:

```
let arr = [ 1, 2, 15 ];

arr.sort(function(a, b) { return a - b; });

alert(arr);  // 1, 2, 15
```

Arrow functions for the best

Remember arrow functions? We can use them here for neater sorting:

```
arr.sort( (a, b) => a - b );
```

This works exactly the same as the other, longer, version above.

reverse

The method arr.reverse reverses the order of elements in `arr`.

For instance:

```
let arr = [1, 2, 3, 4, 5];
arr.reverse();

alert( arr ); // 5,4,3,2,1
```

It also returns the array `arr` after the reversal.

split and join

Here's the situation from the real life. We are writing a messaging app, and the person enters the comma-delimited list of receivers: `John, Pete, Mary`. But for us an array of names would be much more comfortable than a single string. How to get it?

The str.split(delim) method does exactly that. It splits the string into an array by the given delimiter `delim`.

In the example below, we split by a comma followed by space:

```
let names = 'Bilbo, Gandalf, Nazgul';

let arr = names.split(', ');

for (let name of arr) {
  alert( `A message to ${name}.` ); // A message to Bilbo  (and other names)
}
```

The `split` method has an optional second numeric argument – a limit on the array length. If it is provided, then the extra elements are ignored. In practice it is rarely used though:

```
let arr = 'Bilbo, Gandalf, Nazgul, Saruman'.split(', ', 2);

alert(arr); // Bilbo, Gandalf
```

Split into letters

The call to `split(s)` with an empty `s` would split the string into an array of letters:

```
let str = "test";

alert( str.split('') ); // t,e,s,t
```

The call arr.join(separator) does the reverse to `split`. It creates a string of `arr` items glued by `separator` between them.

For instance:

```
let arr = ['Bilbo', 'Gandalf', 'Nazgul'];

let str = arr.join(';');

alert( str ); // Bilbo;Gandalf;Nazgul
```

reduce/reduceRight

When we need to iterate over an array – we can use `forEach`, `for` or `for..of`.

When we need to iterate and return the data for each element – we can use `map`.

The methods arr.reduce and arr.reduceRight also belong to that breed, but are a little bit more intricate. They are used to calculate a single value based on the array.

The syntax is:

```
let value = arr.reduce(function(previousValue, item, index, array) {
  // ...
}, initial);
```

The function is applied to the elements. You may notice the familiar arguments, starting from the 2nd:

- `item` – is the current array item.
- `index` – is its position.
- `array` – is the array.

So far, like `forEach/map`. But there's one more argument:

- `previousValue` – is the result of the previous function call, `initial` for the first call.

The easiest way to grasp that is by example.

Here we get a sum of array in one line:

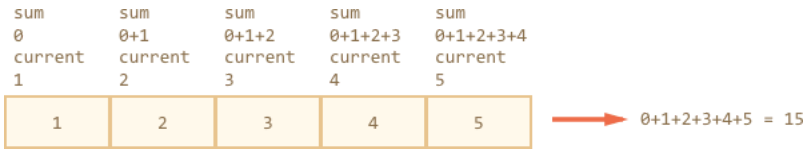
```
let arr = [1, 2, 3, 4, 5];

let result = arr.reduce((sum, current) => sum + current, 0);

alert(result); // 15
```

Here we used the most common variant of `reduce` which uses only 2 arguments.

Let's see the details of what's going on.

1. On the first run, `sum` is the initial value (the last argument of `reduce`), equals `0`, and `current` is the first array element, equals `1`. So the result is `1`.
2. On the second run, `sum = 1`, we add the second array element (`2`) to it and return.
3. On the 3rd run, `sum = 3` and we add one more element to it, and so on...

The calculation flow:



Or in the form of a table, where each row represents a function call on the next array element:

	sum	current	result
the first call	0	1	1
the second call	1	2	3
the third call	3	3	6
the fourth call	6	4	10
the fifth call	10	5	15

As we can see, the result of the previous call becomes the first argument of the next one.

We also can omit the initial value:

```
let arr = [1, 2, 3, 4, 5];

// removed initial value from reduce (no 0)
let result = arr.reduce((sum, current) => sum + current);

alert( result ); // 15
```

The result is the same. That's because if there's no initial, then `reduce` takes the first element of the array as the initial value and starts the iteration from the 2nd element.

The calculation table is the same as above, minus the first row.

But such use requires an extreme care. If the array is empty, then `reduce` call without initial value gives an error.

Here's an example:

```
let arr = [];

// Error: Reduce of empty array with no initial value
// if the initial value existed, reduce would return it for the empty arr.
arr.reduce((sum, current) => sum + current);
```

So it's advised to always specify the initial value.

The method arr.reduceRight does the same, but goes from right to left.

Array.isArray

Arrays do not form a separate language type. They are based on objects.

So `typeof` does not help to distinguish a plain object from an array:

```
alert(typeof {}); // object
alert(typeof []); // same
```

...But arrays are used so often that there's a special method for that: Array.isArray(value). It returns `true` if the `value` is an array, and `false` otherwise.

```
alert(Array.isArray({})); // false

alert(Array.isArray([])); // true
```

Most methods support "thisArg"

Almost all array methods that call functions – like `find`, `filter`, `map`, with a notable exception of `sort`, accept an optional additional parameter `thisArg`.

That parameter is not explained in the sections above, because it's rarely used. But for completeness we have to cover it.

Here's the full syntax of these methods:

```
arr.find(func, thisArg);
arr.filter(func, thisArg);
arr.map(func, thisArg);
// ...
// thisArg is the optional last argument
```

The value of `thisArg` parameter becomes `this` for `func`.

For instance, here we use an object method as a filter and `thisArg` comes in handy:

```
let user = {
  age: 18,
  younger(otherUser) {
    return otherUser.age < this.age;
  }
};

let users = [
  {age: 12},
  {age: 16},
  {age: 32}
];

// find all users younger than user
let youngerUsers = users.filter(user.younger, user);

alert(youngerUsers.length); // 2
```

In the call above, we use `user.younger` as a filter and also provide `user` as the context for it. If we didn't provide the context, `users.filter(user.younger)` would call `user.younger` as a standalone function, with `this=undefined`. That would mean an instant error.

Summary

A cheatsheet of array methods:

- To add/remove elements:
  - `push(...items)` – adds items to the end,
  - `pop()` – extracts an item from the end,
  - `shift()` – extracts an item from the beginning,
  - `unshift(...items)` – adds items to the beginning.
  - `splice(pos, deleteCount, ...items)` – at index `pos` delete `deleteCount` elements and insert `items`.
  - `slice(start, end)` – creates a new array, copies elements from position `start` till `end` (not inclusive) into it.
  - `concat(...items)` – returns a new array: copies all members of the current one and adds `items` to it. If any of `items` is an array, then its elements are taken.
- To search among elements:
  - `indexOf/lastIndexOf(item, pos)` – look for `item` starting from position `pos`, return the index or `-1` if not found.
  - `includes(value)` – returns `true` if the array has `value`, otherwise `false`.
  - `find/filter(func)` – filter elements through the function, return first/all values that make it return `true`.
  - `findIndex` is like `find`, but returns the index instead of a value.
- To iterate over elements:
  - `forEach(func)` – calls `func` for every element, does not return anything.
- To transform the array:
  - `map(func)` – creates a new array from results of calling `func` for every element.
  - `sort(func)` – sorts the array in-place, then returns it.
  - `reverse()` – reverses the array in-place, then returns it.
  - `split/join` – convert a string to array and back.
  - `reduce(func, initial)` – calculate a single value over the array by calling `func` for each element and passing an intermediate result between the calls.
- Additionally:
  - `Array.isArray(arr)` checks `arr` for being an array.

Please note that methods `sort`, `reverse` and `splice` modify the array itself.

These methods are the most used ones, they cover 99% of use cases. But there are few others:

- arr.some(fn)/arr.every(fn) checks the array.

  The function `fn` is called on each element of the array similar to `map`. If any/all results are `true`, returns `true`, otherwise `false`.
- arr.fill(value, start, end) – fills the array with repeating `value` from index `start` to `end`.
- arr.copyWithin(target, start, end) – copies its elements from position `start` till position `end` into *itself*, at position `target` (overwrites existing).

For the full list, see the manual.

From the first sight it may seem that there are so many methods, quite difficult to remember. But actually that's much easier than it seems.

Look through the cheatsheet just to be aware of them. Then solve the tasks of this chapter to practice, so that you have experience with array methods.

Afterwards whenever you need to do something with an array, and you don't know how – come here, look at the cheatsheet and find the right method. Examples will help you to write it correctly. Soon you'll automatically remember the methods, without specific efforts from your side.

Tasks

Translate border-left-width to borderLeftWidth

importance: 5

Write the function `camelize(str)` that changes dash-separated words like "my-short-string" into camel-cased "myShortString".

That is: removes all dashes, each word after dash becomes uppercased.

Examples:

```
camelize("background-color") == 'backgroundColor';
camelize("list-style-image") == 'listStyleImage';
camelize("-webkit-transition") == 'WebkitTransition';
```

P.S. Hint: use `split` to split the string into an array, transform it and `join` back.

Open a sandbox with tests.

solution

Open the solution with tests in a sandbox.

Filter range

importance: 4

Write a function `filterRange(arr, a, b)` that gets an array `arr`, looks for elements between `a` and `b` in it and returns an array of them.

The function should not modify the array. It should return the new array.

For instance:

```
let arr = [5, 3, 8, 1];

let filtered = filterRange(arr, 1, 4);

alert( filtered ); // 3,1 (matching values)

alert( arr ); // 5,3,8,1 (not modified)
```

Open a sandbox with tests.

solution

```
function filterRange(arr, a, b) {
  // added brackets around the expression for better readability
  return arr.filter(item => (a <= item && item <= b));
}

let arr = [5, 3, 8, 1];

let filtered = filterRange(arr, 1, 4);

alert( filtered ); // 3,1 (matching values)

alert( arr ); // 5,3,8,1 (not modified)
```

Open the solution with tests in a sandbox.

Filter range "in place"

importance: 4

Write a function `filterRangeInPlace(arr, a, b)` that gets an array `arr` and removes from it all values except those that are between `a` and `b`. The test is: `a ≤ arr[i] ≤ b`.

The function should only modify the array. It should not return anything.

For instance:

```
let arr = [5, 3, 8, 1];

filterRangeInPlace(arr, 1, 4); // removed the numbers except from 1 to 4

alert( arr ); // [3, 1]
```

Open a sandbox with tests.

solution

```
function filterRangeInPlace(arr, a, b) {

  for (let i = 0; i < arr.length; i++) {
    let val = arr[i];

    // remove if outside of the interval
    if (val < a || val > b) {
      arr.splice(i, 1);
      i--;
    }
  }

}

let arr = [5, 3, 8, 1];

filterRangeInPlace(arr, 1, 4); // removed the numbers except from 1 to 4

alert( arr ); // [3, 1]
```

Open the solution with tests in a sandbox.

Sort in the reverse order

importance: 4

```
let arr = [5, 2, 1, -10, 8];

// ... your code to sort it in the reverse order

alert( arr ); // 8, 5, 2, 1, -10
```

solution

```
let arr = [5, 2, 1, -10, 8];

arr.sort((a, b) => b - a);

alert( arr );
```

Copy and sort array

importance: 5

We have an array of strings `arr`. We'd like to have a sorted copy of it, but keep `arr` unmodified.

Create a function `copySorted(arr)` that returns such a copy.

```
let arr = ["HTML", "JavaScript", "CSS"];

let sorted = copySorted(arr);

alert( sorted ); // CSS, HTML, JavaScript
alert( arr ); // HTML, JavaScript, CSS (no changes)
```

solution

We can use `slice()` to make a copy and run the sort on it:

```
function copySorted(arr) {
  return arr.slice().sort();
}

let arr = ["HTML", "JavaScript", "CSS"];

let sorted = copySorted(arr);

alert( sorted );
alert( arr );
```

Create an extendable calculator

importance: 5

Create a constructor function `Calculator` that creates "extendable" calculator objects.

The task consists of two parts.

1. First, implement the method `calculate(str)` that takes a string like `"1 + 2"` in the format "NUMBER operator NUMBER" (space-delimited) and returns the result. Should understand plus `+` and minus `-`.

   Usage example:

   ```
   let calc = new Calculator;

   alert( calc.calculate("3 + 7") ); // 10
   ```

2. Then add the method `addMethod(name, func)` that teaches the calculator a new operation. It takes the operator `name` and the two-argument function `func(a,b)` that implements it.

   For instance, let's add the multiplication `*`, division `/` and power `**`:

   ```
   let powerCalc = new Calculator;
   powerCalc.addMethod("*", (a, b) => a * b);
   powerCalc.addMethod("/", (a, b) => a / b);
   powerCalc.addMethod("**", (a, b) => a ** b);

   let result = powerCalc.calculate("2 ** 3");
   alert( result ); // 8
   ```

- No brackets or complex expressions in this task.
- The numbers and the operator are delimited with exactly one space.
- There may be error handling if you'd like to add it.

Open a sandbox with tests.

solution

- Please note how methods are stored. They are simply added to the internal object.
- All tests and numeric conversions are done in the `calculate` method. In future it may be extended to support more complex expressions.

Open the solution with tests in a sandbox.

Map to names

importance: 5

You have an array of `user` objects, each one has `user.name`. Write the code that converts it into an array of names.

For instance:

```
let john = { name: "John", age: 25 };
let pete = { name: "Pete", age: 30 };
let mary = { name: "Mary", age: 28 };

let users = [ john, pete, mary ];

let names = /* ... your code */

alert( names ); // John, Pete, Mary
```

solution

```
let john = { name: "John", age: 25 };
let pete = { name: "Pete", age: 30 };
let mary = { name: "Mary", age: 28 };

let users = [ john, pete, mary ];

let names = users.map(item => item.name);

alert( names ); // John, Pete, Mary
```

Map to objects

importance: 5

You have an array of `user` objects, each one has `name`, `surname` and `id`.

Write the code to create another array from it, of objects with `id` and `fullName`, where `fullName` is generated from `name` and `surname`.

For instance:

```
let john = { name: "John", surname: "Smith", id: 1 };
let pete = { name: "Pete", surname: "Hunt", id: 2 };
let mary = { name: "Mary", surname: "Key", id: 3 };

let users = [ john, pete, mary ];

let usersMapped = /* ... your code ... */

/*
usersMapped = [
  { fullName: "John Smith", id: 1 },
  { fullName: "Pete Hunt", id: 2 },
  { fullName: "Mary Key", id: 3 }
]
*/

alert( usersMapped[0].id ) // 1
alert( usersMapped[0].fullName ) // John Smith
```

So, actually you need to map one array of objects to another. Try using `=>` here. There's a small catch.

solution

```
let john = { name: "John", surname: "Smith", id: 1 };
let pete = { name: "Pete", surname: "Hunt", id: 2 };
let mary = { name: "Mary", surname: "Key", id: 3 };

```

```
let users = [ john, pete, mary ];

let usersMapped = users.map(user => ({
  fullName: `${user.name} ${user.surname}`,
  id: user.id
}));

/*
usersMapped = [
  { fullName: "John Smith", id: 1 },
  { fullName: "Pete Hunt", id: 2 },
  { fullName: "Mary Key", id: 3 }
]
*/

alert( usersMapped[0].id ); // 1
alert( usersMapped[0].fullName ); // John Smith
```

Please note that in for the arrow functions we need to use additional brackets.

We can't write like this:

```
let usersMapped = users.map(user => {
  fullName: `${user.name} ${user.surname}`,
  id: user.id
});
```

As we remember, there are two arrow functions: without body `value => expr` and with body `value => {...}`.

Here JavaScript would treat `{` as the start of function body, not the start of the object. The workaround is to wrap them in the "normal" brackets:

```
let usersMapped = users.map(user => ({
  fullName: `${user.name} ${user.surname}`,
  id: user.id
}));
```

Now fine.

Sort objects

importance: 5

Write the function `sortByName(users)` that gets an array of objects with the `age` property and sorts them by `age`.

For instance:

```
let john = { name: "John", age: 25 };
let pete = { name: "Pete", age: 30 };
let mary = { name: "Mary", age: 28 };

let arr = [ john, pete, mary ];

sortByName(arr);

// now: [john, mary, pete]
alert(arr[0].name); // Mary
alert(arr[2].name); // Pete
```

solution

```
function sortByName(arr) {
  arr.sort((a, b) => a.age > b.age ? 1 : -1);
}

let john = { name: "John", age: 25 };
let pete = { name: "Pete", age: 30 };
let mary = { name: "Mary", age: 28 };

let arr = [ john, pete, mary ];
```

```
10
11  sortByName(arr);
12
13  // now sorted is: [john, mary, pete]
14  alert(arr[0].name); // John
15  alert(arr[2].name); // Pete
```

Shuffle an array

importance: 3

Write the function `shuffle(array)` that shuffles (randomly reorders) elements of the array.

Multiple runs of `shuffle` may lead to different orders of elements. For instance:

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

shuffle(arr);
// arr = [3, 2, 1]

shuffle(arr);
// arr = [2, 1, 3]

shuffle(arr);
// arr = [3, 1, 2]
// ...
```

All element orders should have an equal probability. For instance, `[1,2,3]` can be reordered as `[1,2,3]` or `[1,3,2]` or `[3,1,2]` etc, with equal probability of each case.

solution

The simple solution could be:

```
function shuffle(array) {
  array.sort(() => Math.random() - 0.5);
}

let arr = [1, 2, 3];
shuffle(arr);
alert(arr);
```

That somewhat works, because `Math.random() - 0.5` is a random number that may be positive or negative, so the sorting function reorders elements randomly.

But because the sorting function is not meant to be used this way, not all permutations have the same probability.

For instance, consider the code below. It runs `shuffle` 1000000 times and counts appearances of all possible results:

```
function shuffle(array) {
  array.sort(() => Math.random() - 0.5);
}

// counts of appearances for all possible permutations
let count = {
  '123': 0,
  '132': 0,
  '213': 0,
  '231': 0,
  '321': 0,
  '312': 0
};

for (let i = 0; i < 1000000; i++) {
  let array = [1, 2, 3];
  shuffle(array);
  count[array.join('')]++;
}

// show counts of all possible permutations
for (let key in count) {
```

```
  alert(`${key}: ${count[key]}`);
}
```

An example result (for V8, July 2017):

```
123: 250706
132: 124425
213: 249618
231: 124880
312: 125148
321: 125223
```

We can see the bias clearly: `123` and `213` appear much more often than others.

The result of the code may vary between JavaScript engines, but we can already see that the approach is unreliable.

Why it doesn't work? Generally speaking, `sort` is a "black box": we throw an array and a comparison function into it and expect the array to be sorted. But due to the utter randomness of the comparison the black box goes mad, and how exactly it goes mad depends on the concrete implementation that differs between engines.

There are other good ways to do the task. For instance, there's a great algorithm called Fisher-Yates shuffle. The idea is to walk the array in the reverse order and swap each element with a random one before it:

```
function shuffle(array) {
  for (let i = array.length - 1; i > 0; i--) {
    let j = Math.floor(Math.random() * (i + 1)); // random index from 0 to i
    [array[i], array[j]] = [array[j], array[i]]; // swap elements
  }
}
```

Let's test it the same way:

```
function shuffle(array) {
  for (let i = array.length - 1; i > 0; i--) {
    let j = Math.floor(Math.random() * (i + 1));
    [array[i], array[j]] = [array[j], array[i]];
  }
}

// counts of appearances for all possible permutations
let count = {
  '123': 0,
  '132': 0,
  '213': 0,
  '231': 0,
  '321': 0,
  '312': 0
};

for (let i = 0; i < 1000000; i++) {
  let array = [1, 2, 3];
  shuffle(array);
  count[array.join('')]++;
}

// show counts of all possible permutations
for (let key in count) {
  alert(`${key}: ${count[key]}`);
}
```

The example output:

```
123: 166693
132: 166647
213: 166628
231: 167517
312: 166199
321: 166316
```

Looks good now: all permutations appear with the same probability.

Also, performance-wise the Fisher-Yates algorithm is much better, there's no "sorting" overhead.

Get average age

importance: 4

Write the function `getAverageAge(users)` that gets an array of objects with property `age` and gets the average.

The formula for the average is `(age1 + age2 + ... + ageN) / N`.

For instance:

```
let john = { name: "John", age: 25 };
let pete = { name: "Pete", age: 30 };
let mary = { name: "Mary", age: 29 };

let arr = [ john, pete, mary ];

alert( getAverageAge(arr) ); // (25 + 30 + 29) / 3 = 28
```

solution

```
function getAverageAge(users) {
  return users.reduce((prev, user) => prev + user.age, 0) / users.length;
}

let john = { name: "John", age: 25 };
let pete = { name: "Pete", age: 30 };
let mary = { name: "Mary", age: 29 };

let arr = [ john, pete, mary ];

alert( getAverageAge(arr) ); // 28
```

Filter unique array members

importance: 4

Let `arr` be an array.

Create a function `unique(arr)` that should return an array with unique items of `arr`.

For instance:

```
function unique(arr) {
  /* your code */
}

let strings = ["Hare", "Krishna", "Hare", "Krishna",
  "Krishna", "Krishna", "Hare", "Hare", ":-O"
];

alert( unique(strings) ); // Hare, Krishna, :-O
```

Open a sandbox with tests.

solution

Let's walk the array items:

- For each item we'll check if the resulting array already has that item.
- If it is so, then ignore, otherwise add to results.

```
function unique(arr) {
  let result = [];

```

```
  for (let str of arr) {
    if (!result.includes(str)) {
      result.push(str);
    }
  }

  return result;
}

let strings = ["Hare", "Krishna", "Hare", "Krishna",
  "Krishna", "Krishna", "Hare", "Hare", ":-O"
];

alert( unique(strings) ); // Hare, Krishna, :-O
```

The code works, but there's a potential performance problem in it.

The method `result.includes(str)` internally walks the array `result` and compares each element against `str` to find the match.

So if there are `100` elements in `result` and no one matches `str`, then it will walk the whole `result` and do exactly `100` comparisons. And if `result` is large, like `10000`, then there would be `10000` comparisons.

That's not a problem by itself, because JavaScript engines are very fast, so walk `10000` array is a matter of microseconds.

But we do such test for each element of `arr`, in the `for` loop.

So if `arr.length` is `10000` we'll have something like `10000*10000` = 100 millions of comparisons. That's a lot.

So the solution is only good for small arrays.

Further in the chapter Map, Set, WeakMap and WeakSet we'll see how to optimize it.

Open the solution with tests in a sandbox.

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