

ECMAScript (ES) 6

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ECMAScript

- Defined by **European Computer Manufacturers Association** (ECMA)
- Specification is called **ECMAScript** or ECMA-262
 - JavaScript 5.1 (**ES5**) - <http://www.ecma-international.org/publications/standards/Ecma-262.htm>
 - JavaScript 6 (**ES6**) - http://wiki.ecmascript.org/doku.php?id=harmony:specification_drafts
 - goal is to finalize in June 2015
- **ECMAScript Technical Committee** is called **TC39**
- TC39 has bi-monthly face-to-face meetings
- Besides defining the standard,
 - “TC39 members create and test implementations of the candidate specification to verify its correctness and the feasibility of creating interoperable implementations.”
- **Current members** include
 - **Brendan Eich** (Mozilla, JavaScript inventor), **Allen Wirfs-Brock** (Mozilla), Dave Herman (Mozilla), Brandon Benvie (Mozilla), Mark Miller (Google), Alex Russell (Google, Dojo Toolkit), Erik Arvidsson (Google, Traceur), Domenic Denicola (Google), Luke Hoban (Microsoft), Yehuda Katz (Tilde Inc., Ember.js), Rick Waldron (Boucoup, jQuery), and many more

ES5 vs. ES6

- ECMAScript 5 did not add any new syntax
- ECMAScript 6 does!
- ES6 is backward compatible with ES5, which is backward compatible with ES3
- Many ES6 features provide **syntactic sugar** for more concise code
- Spec sizes
 - **ES5 - 258 pages**
 - **ES6 - 652 pages** (draft on 2/20/15)
- One goal of ES6 and beyond is to make JavaScript a **better target for compiling to from other languages**

“One JavaScript”

- Approach named by David Herman
- Allows JavaScript to evolve without versioning
 - avoids migration issues like Python 2 to Python 3
- “Don’t break the web!”
 - removing features would cause existing web apps to stop working
 - can add new, better features
 - ES5 strict mode was a bit of a mistake since it broke some existing code
 - this is why ES6 supports “sloppy mode” code outside modules and class definitions
- Use linting tools to detect use of “deprecated” features
 - ex. switching from `var` to `let` and `const` and using rest parameters in place of `arguments` object

Transpilers

- Compilers translate code one language to another
 - ex. Java to bytecode
- Transpilers translate code to the same language
- There are several transpilers that translate ES6 code to ES5

ES6 Transpilers

percentages are as of 3/18/15

- **Traceur - 64%**

- from Google
- generates source maps
- doesn't work with IE8 and below
 - due to use of ES5 `get/set` syntax
- <https://github.com/google/traceur-compiler/>

- **Babel - 76%**

- aims to generate ES5 code that is as close as possible to the input ES6 code
- generates source maps
- some features don't work with IE10 and below
 - see <https://babeljs.io/docs/usage/caveats/#internet-explorer>
- <https://babeljs.io>

- **TypeScript - 9%**

- from Microsoft
- "a typed superset of JavaScript that compiles to plain JavaScript. Any browser. Any host. Any OS. Open Source."
- supports optional type specifications for variables, function return values, and function parameters
- has goal to support all of ES6
- generates source maps
- to install, `npm install -g typescript`
- to compile, `tsc some-file.ts`
 - generates `some-file.js`
- <http://www.typescriptlang.org>

there are more, but these are the most popular and/or support the most features

Use ES6 Today?

- It **may take years** for all the features in ES6 to be supported in all major browsers
- That's **too long to wait** and you **don't have to wait**
- **Use a transpiler** to get comfortable with new features sooner and allow writing more compact, more expressive code now
- For a **summary of ES6 feature support in browsers**, and in the Traceur tool discussed next, see ES6 compatibility table from Juriy Zaytsev (a.k.a. kangax)
 - <http://kangax.github.io/compat-table/es6/>
 - try selecting "Sort by number of features?" checkbox

ECMAScript 5 6 7 non-standard compatibility table

Please note that some of these tests represent **existence**, not functionality or full conformance. Sort by number of features? Show obsolete browsers?

Feature name	Current browser	Compilers/polyfills								Desktop browsers									
		Traceur	6to5 + core-js ⁽¹⁾	ES6 Transpiler	Closure	jsx ⁽²⁾	Type-Script	es6-shim	IE 10	IE 11	IE Technical Preview ⁽³⁾	FF 31	FF 35	FF 36	FF 37	CH 39, OP 26 ⁽⁴⁾	CH 4, OP 2 ⁽⁵⁾		
Optimisation	52%	60%	76%	27%	26%	10%	8%	23%	6%	21%	70%	44%	60%	68%	69%	34%			
proper tail calls (tail call optimisation)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No			
Syntax																			
default function parameters	0/5	3/5	5/5	3/5	4/5	0/5	3/5	0/5	0/5	0/5	0/5	3/5	3/5	3/5	3/5	0/5	0/5		
rest parameters	0/3	3/3	3/3	2/3	1/3	2/3	2/3	0/3	0/3	0/3	2/3	2/3	2/3	2/3	2/3	0/3	0/3		
spread (...) operator	0/8	8/8	8/8	6/8	2/8	0/8	0/8	0/8	0/8	0/8	4/8	6/8	6/8	8/8	8/8	0/8	0/8		
object literal extensions	2/5	5/5	5/5	5/5	4/5	2/5	2/5	0/5	0/5	0/5	5/5	0/5	5/5	5/5	5/5	0/5	0/5		

Traceur

- **Implemented in ES6** and uses itself to transpile to ES5 code that runs on Node.js
- <https://github.com/google/traceur-compiler>
- **Online tool** at <http://google.github.io/traceur-compiler/demo/repl.html>
 - enter ES6 on left side and see resulting ES5 code on right
 - useful for testing support for specific ES6 features and gaining an understanding of what Traceur generates
 - does not execute code
 - "Options" menu includes ability to enable experimental features
- **To install**
 - install Node.js
 - `npm install -g traceur`

AngularJS 2 uses Traceur
for ES6 support

Running Traceur

- To get help on options
 - `traceur --help`
 - `traceur --longhelp`
- To run code in an ES6 file
 - `traceur es6-file-path`
 - requires file extension to be `.js`, but it can be omitted in the command
- To compile an ES6 file to an ES5 file
 - `traceur --out es5-file-path es6-file-path`
 - generated code depends on provided file `traceur-runtime.js`
 - can be copied from directory where Traceur is installed
 - to use generated code in a browser, include a script tag for `traceur-runtime.js`
- Experimental features
 - to use, add `--experimental` option
 - examples of features currently considered experimental include symbols, `async/await` keywords, and type annotations

doesn't check for native browser support;
does some feature detection like not
adding shim methods if already present

Babel

- **Implemented in ES6** and uses itself to transpile to ES5 code that runs on Node.js
- <http://babeljs.io>
- **Online tool** at <http://babeljs.io/repl/>
 - enter ES6 on left side and see resulting ES5 code on right
 - useful for testing support for specific ES6 features and gaining an understanding of what Babel generates
 - optionally executes code (when "Evaluate" checkbox is checked)
 - output is at bottom of ES5 code
 - "Experimental" and "Playground" checkboxes enable ES7 features and other "ideas"
- **To install**
 - install Node.js
 - `npm install -g babel`

"Babel works perfectly with React, featuring a built-in JSX transformer."

Running Babel

- To get help on options
 - `babel --help`
- To run code in an ES6 file
 - `babel-node es6-file-path`
 - file extension can be omitted and defaults to `.js`
- To compile an ES6 file to an ES5 file
 - `babel es6-file-path -o es5-file-path`
- To compile a many ES6 files to ES5 files
 - `babel es6-dir -o es5-dir`
- Experimental features
 - to use some ES7 features, add `--experimental` option
- Optional babel-runtime
 - <http://babeljs.io/docs/usage/transformers/#self-contained>

in *nix environments, can use redirection
`babel es6-file-path > es5-file-path`

Source Maps

- Allow browser debuggers to step through code that was transpiled from another language into JavaScript
 - for example, debug CoffeeScript code
 - can debug ES6 code that was transpiled to ES5
- **Traceur**
 - option `--source-maps` causes it to generate a source map
 - places them in same directory as generated ES5 files
 - browser looks for them there
- **Babel**
 - plugins for Grunt and Gulp can generate source maps

Using Source Maps

- In Chrome

- open a page that uses transpiled ES6 code
- open Developer Tools (cmd-option-i on Mac, ctrl-shift-i on Windows)
- click gear icon in upper-right to see settings
- check "Search in content scripts"
- check "Enable JavaScript source maps"
- select ES6 .js files from "Sources" tab
- set breakpoints and refresh page

- In Firefox

- open Firefox debugger by selecting Tools ... Web Developer ... Debugger (cmd-option-s on Mac, ctrl-shift-s on Windows?)
- click gear icon in upper-right to see "Debugger Options" and verify that "Show Original Sources" is selected
- select ES6 .js files from "Sources" tab
- set breakpoints and refresh page

Linting

- It is important to use some linting tool when writing JavaScript
- Saves time and reduces errors by catching coding issues before code is run
- Can be run from command-line, integrated into editors/IDEs, and run automatically when files are saved from any editor using tools like Grunt/Gulp
- Most popular JavaScript linting tools
 - JSLint - <http://jshint.org>; unclear if or when JSLint will support ES6
 - JSHint - <http://jshint.org>; has good support now using "**esnext**" option
 - ESLint - <http://eslint.org>; recently added support ES6; needs more testing
- I highly recommend using JSHint to check ES6 code

Automation

- **Grunt** - <http://gruntjs.com>
 - great tool for automating web development tasks
 - 4,472 plugins available as of 3/8/15
 - for Traceur support, see these plugins: traceur, traceur-latest, traceur-build, **traceur-simple**, and node-traceur
 - for Babel support, see the plugin grunt-babel
 - see example **Gruntfile.js** in article
 - uses "**watch**" plugin to watch for changes to HTML, CSS and JavaScript files
 - when watch detects these, it automatically runs specified tasks including linting CSS and JavaScript, running Traceur to generate ES5 code, and refreshing browser to immediately show results of changes
 - last part is enabled by "**livereload**" option and including a special script tag in main HTML file
- **Gulp** - <http://gulpjs.com>
 - similar in goal to Grunt, but configuration is different
 - 1,457 plugins available as of 3/8/15
 - also supports watch and livereload
 - emphasizes use of file streaming for better efficiency
 - see gulp-traceur and gulp-babel plugins

see Grunt and Gulp examples at
<https://github.com/mvolkmann/gulp-traceur-demo>

ES6 Features

- The following slides describe most of the features in ES6
- Also see Luke Hoban's (TC39 member) summary
 - <https://github.com/lukehoban/es6features>

Block Scope ...

- **const** declares constants with block scope
 - must be initialized
 - reference can't be modified, but object values can
 - to prevent changes to object values, use `Object.freeze(obj)`
- **let** declares variables like **var**, but they have block scope
 - not hoisted to beginning of enclosing block, so references before declaration are errors
 - most uses of **var** can be replaced with **let** (not if they depend on hoisting)
 - when a file defines a module, top-level uses of **let** are file-scoped, unlike **var**
 - Traceur and Babel implement block scopes by renaming variables declared in block
 - when a **let** variable is accessed out of its scope, a **ReferenceError** is thrown with message "`name is not defined`"

... Block Scope

- block functions
 - functions declared in a block are scoped to that block
 - for example, in if and for-loop blocks

```
function outer() {  
  console.log('in outer');  
}  
  
{  
  function inner() {  
    console.log('in inner');  
  }  
  
  outer(); // works  
  inner(); // works  
}  
  
outer(); // works  
inner(); // throws ReferenceError
```

Default Parameters



- Example

```
let today = new Date();

function makeDate(day, month = today.getMonth(), year = today.getFullYear()) {
  return new Date(year, month, day).toLocaleDateString();
}

console.log(makeDate(16, 3, 1961)); // Sun Apr 16 1961
console.log(makeDate(16, 3)); // Wed Apr 16 2014
console.log(makeDate(16)); // Sun Feb 16 2014
```

run on 2/28/14

- Default value expressions can return to preceding parameters
- Explicitly passing undefined triggers use of default value
- Idiom for required parameters (from Allen Wirfs-Brock)

```
function req() { throw new Error('missing argument'); }
function foo(p1 = req(), p2 = req(), p3 = undefined) {
  ...
}
```



Rest Operator

- Gather variable number of arguments after named parameters into an array
- If no corresponding arguments are supplied, value is an empty array, not undefined
- Removes need to use `arguments` object

```
function report(firstName, lastName, ...colors) {
  let phrase = colors.length === 0 ? 'no colors' :
    colors.length === 1 ? 'the color ' + colors[0]:
    'the colors ' + colors.join(' and ');
  console.log(firstName, lastName, 'likes', phrase + '.');
}

report('John', 'Doe');
// John Doe likes no colors.
report('Mark', 'Volkman', 'yellow');
// Mark Volkman likes the color yellow.
report('Tami', 'Volkman', 'pink', 'blue');
// Tami Volkman likes the colors pink and blue.
```

Spread Operator



- Spreads out elements of any “iterable” (discussed later) so they are treated as separate arguments to a function
- Mostly removes need to use **Function apply** method
- Examples

examples of things that are iterable include arrays, sets, and strings

```
let arr1 = [1, 2];
let arr2 = [3, 4];
arr1.push(...arr2);
console.log(arr1); // [1, 2, 3, 4]

let dateParts = [1961, 3, 16];
let birthday = new Date(...dateParts);
console.log(birthday.toString());
// Sun Apr 16, 1961
```

alternative to
`arr1.push.apply(arr1, arr2);`

Destructuring ...



- Assigns values to any number of variables from values in arrays and objects

```
// Positional destructuring of iterables
let [var1, var2] = some-iterable;
// Can skip elements (elision)
let [, var1, , var2] = some-iterable;

// Property destructuring of objects
let {prop1: var1, prop2: var2} = some-obj;
// Can omit variable name if same as property name
let {prop1, prop2} = some-obj;
```

- Can be used in variable declarations/assignments, parameter lists, and for-of loops (covered later)
- Can't start statement with {, so add parens when assigning to existing variables using object destructuring,

```
(({prop1: var1, prop2: var2})) = some-obj;
```

- LHS expression can be nested to any depth
 - arrays of objects, objects whose property values are arrays, ...

... Destructuring ...



- LHS variables can specify default values

```
[var1 = 19, var2] = some-iterable;
```

- default values can refer to variables that precede their variable
- Positional destructuring can use rest operator for last variable

```
[var1, ...others] = some-iterable;
```

- When assigning rather than declaring variables, any valid LHS variable expression can be used

- ex. `obj.prop` and `arr[index]`

- Can be used to swap variable values

```
[a, b] = [b, a];
```

- Useful with functions that have multiple return values
 - really one array or object



... Destructuring ...

- Great for getting parenthesized groups of a **RegExp** match

```
let dateStr = 'I was born on 4/16/1961 in St. Louis.';
let re = /(\\d{1,2})\\/(\\d{1,2})\\/(\\d{4})/;
let [, month, day, year] = re.exec(dateStr);
console.log('date pieces =', month, day, year);
```

- Great for configuration kinds of parameters of any time named parameters are desired (common when many)

```
function config({color, size, speed = 'slow', volume}) {
  console.log('color =', color); // yellow
  console.log('size =', size); // 33
  console.log('speed =', speed); // slow
  console.log('volume =', volume); // 11
}

config({
  size: 33,
  volume: 11,
  color: 'yellow'
});
```

order is
irrelevant



... Destructuring

```
function report([name, color]) {
  console.log(name + "'s favorite color is", color + '.');
}
let data = ['Mark', 'yellow'];
report(data); // Mark's favorite color is yellow.

let arr = [1, [2, 3], [[4, 5], [6, 7, 8]]];
let [a, [, b], [[c], [, d]]] = arr;
console.log('a =', a); // 1
console.log('b =', b); // 3
console.log('c =', c); // 4
console.log('d =', d); // 8

let obj = {color: 'blue', weight: 1, size: 32};
let {color, size} = obj;
console.log('color =', color); // blue
console.log('size =', size); // 32

function report2(p1, {weight, color}) {
  console.log(p1, color, weight);
}
report2(19, obj); // 19 blue 1
```

extracting array
elements
by position

extracting object
property values
by name

Arrow Functions ...

- `(params) => { expressions }`
 - if only one parameter and not using destructuring, can omit parens
 - need parens if no parameters
 - cannot insert line feed between parameters and `=>`
 - if only one expression, can omit braces and its value is returned without using `return` keyword
 - `expression` can be another arrow function that is returned
 - if expression is an object literal, wrap it in parens to distinguish it from a block of code

```
let arr = [1, 2, 3, 4];  
let doubled = arr.map(x => x * 2);  
console.log(doubled); // [2, 4, 6, 8]
```

```
let product = (a, b) => a * b;  
console.log(product(2, 3)); // 6
```

```
let average = numbers => {  
  let sum = numbers.reduce((a, b) => a + b);  
  return sum / numbers.length;  
};  
console.log(average(arr)); // 2.5
```

Arrow functions are typically used for anonymous functions like those passed to `map` and `reduce`.

Functions like `product` and `average` are better defined the normal way so their names appear in stack traces.

... Arrow Functions

- Inside arrow function, **this** has same value as containing scope, not a new value (called "lexical this")
 - so can't use to define constructor functions or methods, only plain functions
- Also provides "lexical super"
- Immediately invoked functions (IIFEs)
 - not typically needed in ES6 since modules provide file scope
 - can write like this

```
(() => {  
  ...  
}) ();
```

- ending like this is a syntax error

```
(() => {  
  ...  
} ());
```

Symbols ...

- Immutable identifiers that are guaranteed to be unique
 - unlike strings
- To create a symbol
 - `let sym = Symbol(description);`
 - note `new` keyword is not used
 - throws `TypeError`; it's a function, not a constructor
 - description is optional and mainly useful for debugging
- To retrieve description
 - `sym.toString()` or `String(sym)`
 - returns `'Symbol(description)'`
 - concatenating a symbol to a string throws `TypeError`
- A new primitive type
 - `typeof sym === 'symbol'`

... Symbols

- Can use as object keys
 - `obj[sym] = value;`
- They become non-enumerable properties
 - `Object.getOwnPropertyNames(obj)` gets string keys, but not symbol keys
 - `Object.getOwnPropertySymbols(obj)` gets symbol keys, but not string keys
 - `Reflect.ownKeys(obj)` gets both string and symbol keys
- Can use for constants that only serve as unique identifiers
 - `const NAME = Symbol();`
- Can use to add “meta-level” properties or internal methods to an object that avoid clashing with normal properties
 - `Symbol.iterator` is an example (described later)
- To use in Traceur and Babel, enable experimental mode

```
// Using computed
// property syntax
let obj = {
  [sym1]: value,
  [sym2](params) {
    ...
  }
};
```

Public Symbols

- There are several predefined symbols that can be used as method names to customize how JavaScript treats specific objects
- To customize `instanceof`, implement `Symbol.hasInstance` method
- To customize conversion to a primitive, implement `Symbol.toPrimitive` method
- To customize conversion to a string, implement `Symbol.toStringTag` method
- To make an object “iterable”, implement `Symbol.iterator` method

unlike constants whose names are all uppercase, these have camelcase names

Enhanced Object Literals ...



- Literal objects can omit value for a key if it's in a variable with the same name
 - similar to destructuring syntax
- Example

```
let fruit = 'apple', number = 19;  
let obj = {fruit, foo: 'bar', number};  
console.log(obj);  
// {fruit: 'apple', foo: 'bar', number: 19}
```


... Enhanced Object Literals ...



- Computed properties names can be specified inline

```
// Old style
let obj = {};
obj[expression] = value;

// New style
let obj = {
  [expression]: value
};
```

one use is to define properties whose keys are symbols instead of strings

... Enhanced Object Literals



- Property method assignment
 - alternative way to attach a method to a literal object
 - example

```
let obj = {
  number: 2,
  multiply: function (n) { // old way
    return this.number * n;
  },
  times(n) { // new way
    return this.number * n;
  },
  // This doesn't work because the
  // arrow function "this" value is not obj.
  product: n => this.number * n
};

console.log(obj.multiply(2)); // 4
console.log(obj.times(3)); // 6
console.log(obj.product(4)); // NaN
```



Classes ...

- Use `class` keyword
- Define constructor and methods inside
 - one constructor function per class
- Really just sugar over existing prototypal inheritance mechanism
 - creates a constructor function with same name as class
 - adds methods to prototype
- Code in class definition is always evaluated in strict mode

```
class Shoe {
  constructor(brand, model, size) {
    this.brand = brand;
    this.model = model;
    this.size = size;
    Shoe.count += 1;
  }
  static createdAny() { return Shoe.count > 0; }
  equals(obj) {
    return obj instanceof Shoe &&
      this.brand === obj.brand &&
      this.model === obj.model &&
      this.size === obj.size;
  }
  toString() {
    return this.brand + ' ' + this.model +
      ' in size ' + this.size;
  }
}
Shoe.count = 0;

let s1 = new Shoe('Mizuno', 'Precision 10', 13);
let s2 = new Shoe('Nike', 'Free 5', 12);
let s3 = new Shoe('Mizuno', 'Precision 10', 13);
console.log('created any?', Shoe.createdAny()); // true
console.log('count =', Shoe.count); // 3
console.log('s2 = ' + s2); // Nike Free 5 in size 12
console.log('s1.equals(s2) =', s1.equals(s2)); // false
console.log('s3.equals(s3) =', s3.equals(s3)); // true
```

class method

not a standard JS method

class property



... Classes ...

- Inherit with **extends** keyword

```
class RunningShoe extends Shoe {  
  constructor(brand, model, size, type) {  
    super(brand, model, size);  
    this.type = type;  
    this.miles = 0;  
  }  
  addMiles(miles) { this.miles += miles; }  
  shouldReplace() { return this.miles >= 500; }  
}
```

```
let rs = new RunningShoe(  
  'Nike', 'Free Everyday', 13, 'lightweight trainer');  
rs.addMiles(400);  
console.log('should replace?', rs.shouldReplace()); // false  
rs.addMiles(200);  
console.log('should replace?', rs.shouldReplace()); // true
```

value after **extends** can be an expression that evaluates to a class/constructor function

inherits both instance and static methods

inside constructor, **super(args)** calls the superclass constructor; can only call **super** like this in a constructor and only once

inside a method, **super.name(args)** calls the superclass method **name**

- In subclasses, constructor **must** call **super(args)** and it must be **before** **this** is accessed because the highest superclass creates the object

this is not set until the call to **super** returns

... Classes



- In a class with no **extends**, omitting **constructor** is the same as specifying **constructor () {}**
- In a class with **extends**, omitting **constructor** is the same as specifying **constructor (...args) { super (...args); }**
- Can extend builtin classes like **Array** and **Error**
 - requires JS engine support; transpilers cannot provide
 - instances of **Array** subclasses can be used like normal arrays
 - instances of **Error** subclasses can be thrown like provided **Error** subclasses
- Precede method names with **"* "** for generators (discussed later)



Getters and Setters

- ES5 supports these using `Object.defineProperty/defineProperties`
- ES6 supports `get` and `set` keywords in class definitions

```
class Shoe {  
  ...  
  get size() {  
    return this._size;  
  }  
  set size(size) {  
    this._size = size;  
  }  
  ...  
}  
let s = new Shoe();  
s.size = 13; // invokes setter  
console.log(s.size); // invokes getter
```

can do more here

using `size` instead of `_size` for the "backing field" would cause a `ModuleEvaluationError` with message "Maximum call stack size exceeded"

can use a `Symbol` in place of `_size` and `_name` to make them a non-enumerable properties

```
class Person {  
  constructor(name) {  
    this._name = name;  
  }  
  get name() {  
    return this._name;  
  }  
}  
let p = new Person('Mark');  
console.log('name is', p.name); // Mark  
p.name = 'Jason';  
// throws ModuleEvaluationError  
// with message "Cannot set property name  
// of #<Person> which has only a getter
```

- ES5 also allows use `get` and `set` in object literals, but that seems less useful

ES5 vs. ES6 Functions

	ES5	ES6
normal function	<code>function</code>	<code>function</code> or <code>arrow function</code>
method	<code>function</code> on prototype	method in <code>class</code>
constructor	<code>function</code>	<code>constructor</code> in <code>class</code>

New **Math** Functions

- **Math.fround**(*number*) - returns nearest single precision floating point number to *number*
- **Math.sign**(*number*) - returns sign of *number*; -1, 0 or 1
- **Math.trunc**(*number*) - returns integer part of *number*
- **Math.cbrt**(*number*) - returns cube root of *number*
- **Math.expm1**(*number*) - returns **exp**(*number*) - 1;
 - **Math.exp** returns e (Euler's constant) raised to *number* power
- **Math.hypot**(*x*, *y*, ...) - returns square root of sum of squares of arguments
- **Math.imul**(*n1*, *n2*) - multiplies two 32-bit integers; for performance
- logarithmic functions - **Math.log1p**(*number*), **Math.log10**(*number*), **Math.log2**(*number*)
 - **Math.log1p** returns **Math.log**(1 + *number*)
- hyperbolic trig functions - **Math.asinh**(*number*), **Math.acosh**(*number*), **Math.atanh**(*number*)

New **Number** Functions

- **Number.isFinite**(*n*) - returns boolean indicating whether *n* is a **Number** and is not **NaN**, **Infinity** or **-Infinity**
- **Number.isInteger**(*n*) - returns boolean indicating whether *n* is an integer and not a float, **NaN**, **Infinity** or **-Infinity**
- **Number.isNaN**(*n*) - returns boolean indicating whether *n* is the special **NaN** value
- **Number.isSafeInteger**(*n*) - returns boolean indicating whether *n* can be represented exactly in a double (within 53 bits)
 - also new constants **Number.MIN_SAFE_INTEGER** and **Number.MAX_SAFE_INTEGER**
- **Number.toInteger**(*n*) - converts a number to an integer
- **Number.parseInt**(*string*) - parses a string into an integer; same as the global function
- **Number.parseFloat**(*string*) - parses a string into a double; same as the global function

note how some of these are functions on other objects in ES5

Numeric Literals

- Hexadecimal
 - preceded with zero and **x**
 - `0xa === 10`
 - supported before ES6
- Octal
 - preceded with zero and **o**
 - `0o71 === 57`
- Binary
 - preceded with zero and **b**
 - `0b1101 === 13`
- When used in strings,
all of these can be parsed with `Number(s)`

New **String** Methods

- **`s1.startsWith(s2)`** - determines if starts with given characters
- **`s1.endsWith(s2)`** - determines if ends with given characters
- **`s1.includes(s2)`** - determines if includes given characters
- **`s.repeat(count)`** - creates new string by copying *s* *count* times
- JavaScript uses UTF-16 characters
 - each occupies two or four bytes
 - **`length`** property of JavaScript strings, as well as **`charAt`** and **`charCodeAt`** methods assume two bytes per character
 - to get length in code points, `[...string].length`
 - no easy way to get or create 4-byte characters in ES5
 - **`string.codePointAt(pos)`** gets UTF-16 integer value at a given position
 - to convert to hex, call **`toString(16)`** on this value
 - **`String.fromCodePoint(int1, ..., intN)`** returns string created from any number of UTF-16 integer values

can specify starting position of test for each of these

ES7 may add **`trimLeft`** and **`trimRight`** methods

use of 4-byte UTF-16 characters is somewhat rare (ex. Egyptian Hieroglyphs), so this is often not a problem

new Unicode escape syntax inside literal strings for specifying a code point **`\u{code}`** (really include the braces)

Template Strings



- String interpolation
- Surrounded by backticks
- Can contain newline characters for multi-line strings

```
let greeting = `Hello,  
World!`;
```

- Can contain any number of embedded expressions
 - `${expression}`

```
console.log(`${x} + ${y} = ${x + y}`);
```

Tagged Template Strings ...



- Preceded by a function name that will produce a customized result
 - examples include special escaping (ex. HTML encoding), language translation, and DSLs
- Passed array of template strings outside expressions (“raw”) and expression values as individual parameters (“cooked”)

```
function upValues(strings, ...values) {  
  let result = strings[0];  
  values.forEach((value, index) =>  
    result += value.toUpperCase() + strings[index + 1]);  
  return result;  
}  
let firstName = 'Mark';  
let lastName = 'Volkmann';  
console.log(upValues `Hello ${firstName} ${lastName}!`);  
// Hello MARK VOLKMANN!
```

In this example
strings is ['Hello ', ' ', '!'] and
values is ['Mark', 'Volkmann']

JSHint doesn't support
tagged template strings yet

- Provided template function `String.raw`
 - treats characters like `\n` as separate `\` and `n` characters

... Tagged Template Strings

```
function dedent(strings, ...values) {
  let last = strings.length - 1, re = /\n\s+/g, result = '';
  for (let i = 0; i < last; i++) {
    result += strings[i].replace(re, '\n') + values[i];
  }
  return result + strings[last];
}

let homeTeam = 'Cardinals';
let visitingTeam = 'Cubs';
console.log(dedent `Today the ${homeTeam}
                  are hosting the ${visitingTeam}.`);

// Outputs
// If template starts with an expression, strings will start with ''.
// If template ends with an expression, strings will end with ''.
console.log(dedent `${homeTeam}
                  versus
                  ${visitingTeam}`);
```

Output

```
Today the Cardinals
are hosting the Cubs.
Cardinals
versus
Cubs
```

New **Array** Functions

- **Array.of**(*values*) - creates an **Array** from its arguments
 - can use literal array syntax instead
- **Array.from**(*arrayLikeObj*, [*mapFn*]) - creates an **Array** from an **Array**-like object
 - *mapFn* is an optional function that is called on each element to transform the value

New **Array** Methods

- **`arr.copyWithin(targetIndex, srcStartIndex, [srcEndIndex])`** - copies elements from `srcStartIndex` to `srcEndIndex - 1`, or to the end of the array, to `targetIndex`, replacing existing elements
 - indexes can be negative to count from end
- **`arr.find(predicateFn)`** - returns first element in `arr` that satisfies a given predicate function
 - `predicateFn` is passed element, index, and `arr`
 - if none satisfy, `undefined` is returned
- **`arr.findIndex(predicateFn)`** - same as `find`, but returns index instead of element
 - if none satisfy, -1 is returned
- **`arr.fill(value, [startIndex], [endIndex])`** - fills `arr` with a given value
 - `startIndex` defaults to 0; `endIndex` defaults to the array length
- **`arr.entries()`** - returns an iterator over the `[index, value]` pairs of `arr`
- **`arr.keys()`** - returns an iterator over the indices of `arr`
- **`arr.values()`** - returns an iterator over the values in `arr`

New Object Functions ...

- **Object.assign**(*target*, *src1*, ... *srcN*)

- copies properties from src objects to target, replacing those already present
- returns *target*
- can use to create a shallow clone an object
- to create a clone with the same prototype

```
let copy = Object.assign({}, obj);
```

```
function clone(obj) {  
  let proto = Object.getPrototypeOf(obj);  
  return Object.assign(  
    Object.create(proto), obj);  
}  
let copy = clone(obj);
```

- can use in constructors to assign initial property values
- can use to add default values to an object

```
const DEFAULTS = {  
  color: 'yellow',  
  size: 'large'  
};  
let obj = {size: 'small'};  
obj = Object.assign({}, DEFAULTS, obj);
```

order is significant!

```
class Shoe {  
  constructor(brand, model, size) {  
    this.brand = brand;  
    this.model = model;  
    this.size = size;  
    // or  
    Object.assign(this,  
      {brand, model, size});  
  }  
  ...  
}
```

uses enhanced object literal

... New Object Functions

- **Object.is**(*value1*, *value2*)
 - determines if *value1* and *value2* are the same
 - values can be primitives or objects; objects are the same only if they are the same object
 - unlike `===`, this treats `Number.NaN` as the same as `Number.NaN`
 - google "MDN JavaScript Object" for more detail
- **Object.setPrototypeOf**(*obj*, *prototype*)
 - changes prototype of an existing object
 - use is discouraged because it is slow and makes subsequent operations on the object slow
- **Object.getOwnPropertySymbols**(*obj*)
 - returns array of symbol keys
 - alternative to existing `Object.keys` and `Object.getOwnPropertyNames` functions
 - also see functions on `Reflect` object (described next)

Reflect Functions

supported by Babel, but not Traceur

- `get(obj, propName)` - alternative to `obj[propName]`
- `set(obj, propName, value)` - alternative to `obj[propName] = value`
- `has(obj, propName)` - alternative to `propName in obj`
- `deleteProperty(obj, propName)` - alternative to `delete obj[propName]`

- `construct(ctorFn, args)` - alternative to using `new ctorFn(...args)`
- `apply(fn, thisValue, args)` - alternative to using `fn.apply(thisValue, args)`

- `getOwnPropertyDescriptor(obj, propName)` - similar to same function in `Object`
- `defineProperty(obj, propName, propAttrs)` - similar to same function in `Object`

- `getPrototypeOf(obj)` - same as function in `Object`
- `setPrototypeOf(obj, prototype)` - changes prototype of `obj`

- `ownKeys(obj)` - returns an array of string and symbol keys
- `enumerate(obj)` - returns an iterator over all string keys (not symbols) including those in prototype chain

- `isExtensible(obj)` - same as function in `Object`
- `preventExtensions(obj)` - similar to same function in `Object`

Getting Object Keys

	string keys	symbol keys	only own	only enumerable
<code>Object.keys</code>	✓		✓	✓
<code>Object.getOwnPropertyNames</code>	✓		✓	
<code>Object.getOwnPropertySymbols</code>		✓	✓	
<code>Reflect.ownKeys</code>	✓	✓	✓	
<code>Reflect.enumerate</code>	✓			✓

for-of Loops

- New way of iterating over elements in an “iterable”
 - for arrays, this is an alternative to for-in loop and `Array.forEach` method
- Iteration variable is scoped to loop
- Value after `of` can be anything that is iterable such as an array
 - iterators are described later
- Example

```
let stooges = ['Moe', 'Larry', 'Curly'];  
for (let stooge of stooges) {  
  console.log(stooge);  
}
```

Collections

- New collection classes include
 - **Set**
 - **Map**
 - **WeakSet**
 - **WeakMap**

Set Class ...

- Instances hold collections of unique values
 - when values are objects, they are compared by reference
- Values can be any type including objects and arrays could store references to DOM nodes
- To create, `let mySet = new Set()`
 - can pass iterable object (such as an array) to constructor to add all its elements
- To add an element, `mySet.add(value)`; can chain to add multiple values
- To test for element, `mySet.has(value)`
- To delete an element, `mySet.delete(value)`
- To delete all elements, `mySet.clear()`

... Set Class

- **size** property holds number of keys
- **keys** method returns iterator over elements
- **values** method returns iterator over elements
 - used by default in for-of loop
- **entries** method returns iterator over [element, element] pairs
- **forEach** method is like in that in **Array**, but passes *value, value* and the set to callback

these
iterate in
insertion
order

methods for **Set** iteration
treat sets like maps
where corresponding keys
and values are equal
for API consistency

iterators are
described later

Common Set Operations

- All of these work by creating **Arrays** from **Sets**, operating on them, and creating a new **Set**

- Map

```
let newSet = new Set([...set].map(elem => some-code));
```

- Filter

```
let newSet = new Set([...set].filter(elem => some-code));
```

- Union

```
let union = new Set([...set1, ...set2]);
```

- Intersection

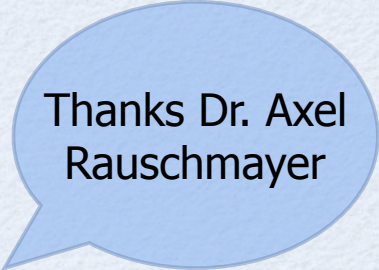
```
let intersection = new Set([...set1].filter(elem => set2.has(elem)));
```

- Difference

```
let union = new Set([...set1].filter(elem => !set2.has(elem)));
```

- Remove duplicates from an array

```
let newArr = [...new Set(arr)];
```



Thanks Dr. Axel Rauschmayer

Set Example

```
let colors = new Set();
colors.add('red');
colors.add('green');
colors.add('blue');
colors.add('red');

// Another way to populate a Set
let arr = ['red', 'green', 'blue', 'red'];
colors = new Set(arr);

console.log(colors.size); // 3
console.log(colors.has('red')); // true
console.log(colors.has('pink')); // false

console.log('\nkeys are:');
colors.forEach(key => console.log(key));
// red green blue
```

```
console.log('\nvalues are:');
for (let value of colors.values()) {
  console.log(value); // red green blue
}
for (let value of colors) { // same
  console.log(value); // red green blue
}

console.log('\nentries are:');
for (let entry of colors.entries()) {
  console.log(entry);
  // ['red', 'red']
  // ['green', 'green']
  // ['blue', 'blue']
}

colors.delete('red');
console.log(colors.size); // 2
console.log(colors.has('red')); // false
```

Map Class ...

- Instances hold key/value pairs where keys are unique
 - when keys are objects, they are compared by reference
- Keys and values can be any type including objects and arrays
 - differs from JavaScript objects in that keys are not restricted to strings
- To create, `let myMap = new Map()`
 - can pass iterable object to constructor to add all its pairs (ex. array of `[key, value]`)
- To add or modify a pair, `map.set(key, value)`
- To get a value, `myMap.get(key)` ;
 - returns `undefined` if not present
- To test for key, `myMap.has(key)`
- To delete a pair, `myMap.delete(key)`
- To delete all pairs, `myMap.clear()`
- `size` property holds number of keys

could use DOM nodes
as keys or values

can chain to add/modify multiple values

... Map Class

- **size** property holds number of keys
- **keys** method returns iterator over keys
- **values** method returns iterator over values
- **entries** method returns iterator over array of [*key*, *value*] arrays
 - used by default in for-of loop
- **forEach** method is like in Array, but passes *value*, *key* and *map* to callback

these
iterate in
insertion
order

Common Map Operations

- Map

an array of key/value arrays

```
let newMap = new Map([...map].map(  
  ([key, value]) => [new-key-expr, new-value-expr]));
```

- Filter

```
let newMap = new Map([...map].filter(  
  ([key, value]) => boolean-expr));
```

Thanks Dr. Axel
Rauschmayer

Map Example

```
let teams = new Map();
teams.set('Chicago', 'Cubs');
teams.set('Kansas City', 'Royals');
teams.set('St. Louis', 'Cardinals');

// Another way to populate a Map
let arr = [
  ['Chicago', 'Cubs'],
  ['Kansas City', 'Royals'],
  ['St. Louis', 'Cardinals']
];
teams = new Map(arr);

console.log(teams.size); // 3
console.log(teams.has('St. Louis')); // true
console.log(teams.has('Los Angeles')); // false
console.log(teams.get('St. Louis')); // Cardinals

console.log('\nkeys are:');
teams.forEach((value, key) => console.log(key));
// Chicago, Kansas City, St. Louis

// Another way to iterate over keys
for (let key of teams.keys()) {
  console.log(key);
  // Chicago, Kansas City, St. Louis
}
```

```
console.log('\nvalues are:');
for (let value of teams.values()) {
  console.log(value);
  // Cubs, Royals, Cardinals
}

console.log('\nentries are:');
for (let entry of teams.entries()) {
  console.log(entry);
  // ['Chicago', 'Cubs']
  // ['Kansas City', 'Royals']
  // ['St. Louis', 'Cardinals']
}
for (let [city, team] of teams) { // same
  console.log(
    'The', team, 'plays in', city);
}

teams.delete('Chicago');
console.log(teams.size); // 2
console.log(teams.has('Chicago')); // false
```

WeakSet Class

supported by Babel, but not Traceur

- Similar API to `Set`, but differs in that
 - values must be objects
 - values are “weakly held”,
i.e. can be garbage collected if not referenced elsewhere
 - don’t have a `size` property
 - can’t iterate over values
 - no `clear` method to remove all elements

WeakMap Class

supported by Babel, but not Traceur

- Similar API to `Map`, but differs in that
 - keys must be objects
 - keys are “weakly held”,
i.e. a pair can be garbage collected if the key is not referenced elsewhere
 - at that point the value can be garbage collected if not referenced elsewhere
 - don’t have a `size` property
 - can’t iterate over keys or values
 - no `clear` method to remove all pairs

Promises ...

- Proxy for a value that may be known in the future after an asynchronous operation completes
- Create with `Promise` constructor, passing it a function that takes `resolve` and `reject` functions
- Register to be notified when promise is **resolved** or **rejected** with `then` or `catch` method
 - `then` method takes success and failure callbacks and returns a `Promise` to support chaining
 - `catch` method only takes failure callback
 - "success callback" is passed a value of any kind
 - "failure callback" is passed a "reason" which can be an `Error` object or a string
- Can call `then` on a promise after it has been resolved or rejected
 - the success or failure callback is called immediately
- Three possible states: pending, fulfilled, and rejected
 - once state is fulfilled or rejected, can't return to pending

call omit
one callback

... Promises ...

```
function asyncDouble(n) {  
  return new Promise((resolve, reject) => {  
    if (typeof n === 'number') {  
      resolve(n * 2);  
    } else {  
      reject(n + ' is not a number');  
    }  
  });  
}  
  
asyncDouble(3).then(  
  data => console.log('data =', data), // 6  
  err => console.error('error:', err));
```

in real usage, some asynchronous operation would happen above

• Static methods

- `Promise.resolve(value)` returns promise that is resolved immediately with given value
- `Promise.reject(reason)` returns promise that is rejected immediately with given reason
- `Promise.all(iterable)` returns promise that is resolved when all promises in *iterable* are resolved
 - resolves to array of results in order of provided promises
 - if any are rejected, this promise is rejected
- `Promise.race(iterable)` returns promise that is resolved when any promise in *iterable* is resolved or rejected when any promise in *iterable* is rejected

... Promises ...

- Supports chaining to reduces code nesting

<pre>asyncDouble(1). then(v => asyncDouble(v)). then(v => asyncDouble(v)). //then(v => asyncDouble('bad')). then(v => console.log('success: v =', v)). catch(err => console.error('error:', err));</pre>	<pre>asyncDouble returns a Promise</pre>
	<pre>Output success: v = 8</pre>

- Some fine print
 - if a success callback returns a non-**Promise** value, it becomes the resolved value of the **Promise** returned by **then**
 - if a success callback returns a **Promise** value, it becomes the **Promise** returned by **then**
 - if any **Promise** in the chain is rejected or throws, the next failure callback in the chain receives it
 - if a failure callback returns a value, it becomes the resolve value for the next success callback in the chain

... Promises

- If an error is thrown inside a success or failure callback the promise returned by **then** is rejected

```
let p = asyncDouble(3).then(  
  v => {  
    // This causes the promise returned by  
    // the call to then above to be rejected.  
    throw 'Did you see this?';  
  },  
  err => console.error('error:', err)); // not reached  
  
p.then(  
  value => console.log('resolved with', value),  
  reason => console.log('rejected with', reason));  
// Output is "rejected with Did you see this?"
```

Modules

- A JavaScript file that is imported by another is treated as a “module”
 - defined by a single, entire source file
 - contents are not wrapped in any special construct
 - also code in an HTML `<module>` tag is treated as a “module” (will anyone use this?)
- Modules typically export values to be shared with other files that import it
- Top-level variables and functions that are not exported are not visible in other source files (like in Node.js)
- Module code is evaluated in strict mode by default
 - no need to specify `'use strict';`
- Supports cyclic module dependencies
- Enables APIs to be defined in modules instead of global variables
 - eliminates need to use objects for namespaces - ex. `JSON` and `Math`
 - future versions of jQuery `$` and Underscore `_` will be defined using modules

Modules - Exporting

- Can export any number of values from a module

- values can be any JavaScript type including functions and classes
- can optionally specify a default export which is actually a named export with the name "default"

- To export a value

- `export let name = value;`
- `export function name(params) { ... }`
- `export class name { ... }`

- To export multiple, previously defined values

- `export {name1, name2 as other-name2, ...};`

note ability to export a value under a different name

- To specify a default export

- `export default expr;`
- `export {name as default};` same as previous line if value of `name` is `expr`
- `export default function (params) { ... };`
- `export default class { ... };`

Modules - Importing

- Can import values from other modules
- To import all exports into a single object
 - `import * as obj from 'module-path';`
 - `obj` is read-only
- To import specific exports
 - `import {name1, name2 as other-name, ...} from 'module-path';`
- To import the default export
 - `import name from 'module-path';`
 - `import {default as name} from 'module-path';`
- To import the default export and specific exports
 - `import default-name, {name1, name2, ...} from 'module-path';`
- To import a module only for its side effects
 - `import 'module-path';`

module paths **do not** include `.js` file extension;
relative to containing file;
can start with `./` (the default) or `../`

note ability to import a value
under a different name

same as previous line

bindings from imports
are read-only

More on Modules

- A module can export values from another module without first importing them

- adds to its own exports

- `export * from 'module-path';` exports everything exported by the given module

- `export {name1, name2 as other-name} from 'module-path';`

- Module Loader API

- supports conditionally loading modules

- allows customized resolving of `'module-path'` strings (see `Reflect.Loader`)

```
System.import('module-path').  
  then(theModule => { ... }).  
  catch(err => { ... });
```

- `System.import` returns a promise

- can use `Promise.all` to wait for multiple modules to be loaded

- there is much more to this!

Modules in Traceur ...


- To transpile ES6 files that use modules
 - transpile just main file to generate a single ES5 file that contains all required code
 - `traceur --out main.js --source-maps main6.js`
- Traceur generated source maps support modules
 - can step through each of the original ES6 files that make up a single generated ES5 file
- Use in browsers requires `traceur-runtime.js`
 - if Traceur was installed using `npm install -g traceur`, determine where global modules are installed with `npm -g root` and copy `traceur-runtime.js` from `traceur/bin` below that directory
 - add `script` tag for this in main HTML file

... Modules in Traceur

<pre>bar6.js export let bar1 = 'the value of bar1'; export function bar2() { console.log('in bar2'); }</pre>	<pre>index.html <html> <head> <title></title> <script src="lib/traceur-runtime.js"></script> <script src="gen/main.js"></script> </head> <body> See console output. </body> </html></pre>
<pre>foo6.js import {bar1, bar2} from './bar6'; export let foo1 = 'the value of foo1'; console.log('foo6: bar1 =', bar1); export function foo2() { console.log('in foo2'); bar2(); }</pre>	<p>To run from command-line: traceur main6</p> <p>To generate ES5 and source map: traceur --out gen/main.js \ --source-maps main6.js</p>
<pre>main6.js import {foo1, foo2} from './foo6'; console.log('in main'); console.log('foo1 =', foo1); foo2();</pre>	<p>Output:</p> <pre>foo6: bar1 = the value of bar1 in main foo1 = the value of foo1 in foo2 in bar2</pre>

Guy Bedford Rocks!



- **ES6 Module Loader** - <https://github.com/ModuleLoader/es6-module-loader>
 - “dynamically loads ES6 modules in browsers and NodeJS”
 - will track “JavaScript Loader Standard” at <https://github.com/whatwg/loader>
- **SystemJS** - <https://github.com/systemjs/systemjs>
 - “universal dynamic module loader - loads ES6 modules (using **ES6 Module Loader**), AMD, CommonJS, and global scripts (like jQuery and lo-dash) in the browser and NodeJS.”
 - dependency management handles circular references and modules that depend on different versions of the same module (like Node.js does)
 - supports “loading assets ... such as CSS, JSON or images”
- **jspm** - <http://jspm.io> and <https://github.com/jspm> 
 - JavaScript Package Manager for **SystemJS**
 - “load any module format (ES6, AMD, CommonJS, and globals) directly from any endpoint such as **npm** and **GitHub**”
 - “custom endpoints can be created”
 - “for development, load modules as separate files with ES6”
 - “for production, optimize into a bundle ... with a single command”

all of these support
Traceur and Babel

Using jspm ...

- **To install and configure jspm**

- `npm install -g jspm`
- `jspm init`
 - prompts and creates `package.json` and `config.js`
 - can accept all defaults
- create `index.html`
- setup a local file server
 - a good option is live-server
 - `npm install -g live-server`
 - `live-server`
- browse localhost:8080
- automatically transpiles using Traceur (default) or Babel
- automatically generates sourcemaps

- **To install modules**

- for packages in npm
 - `jspm install npm:module-name` (ex. jsonp)
 - by default, installs in `jspm_packages/npm`
- for packages in GitHub
 - `jspm install github:module-name`
 - by default, installs in `jspm_packages/github`
- for well-known packages
 - `jspm install module-name`
 - includes angularjs, bootstrap, d3, jquery, lodash, moment, and underscore
 - see list at <https://github.com/jspm/registry/blob/master/registry.json>
- adds dependencies to `package.json`
- adds `System.config` call in `config.js`

lesser used modules
require jspm configuration
before they can be installed

... Using jspm

- **To reinstall dependencies**

- similar to npm, run `jspm install`
- recreates and populates `jspm_packages` directory
- recreates `config.js` if it is missing

- **To make your own packages compatible with jspm**

- see <https://github.com/jspm/registry/wiki/Configuring-Packages-for-jspm>
- can publish in npm or GitHub
- allows others to install them using jspm

- **To bundle for production**

- `jspm bundle-sfx --minify main`
- removes all dynamic loading and transpiling
- generates `build.js` and `build.js.map`
- replace all script tags in main HTML file with one for `build.js`
- if using Traceur, add

```
<script src="jspm_packages/traceur-runtime.js">  
</script>
```
- there are other bundling options, but this seems like the best
- won't be necessary in the future when browsers support HTTP2
 - will be able to download many files efficiently
 - today browsers limit concurrent HTTP requests to the same domain to 6 or 8

sfx is short for "self executing"

jspm Example #1

the basics plus a little jQuery

```
jspm install jquery
```

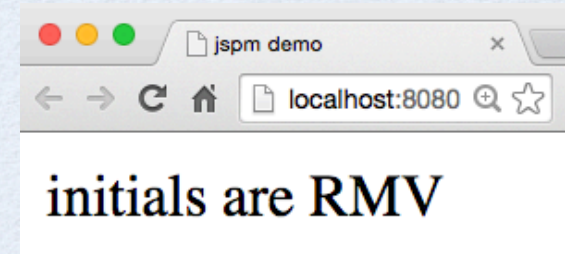
```
<!DOCTYPE html>
<html>
  <head>...</head>
  <body>
    <div id="content"></div>

    <!-- Enable ES6 module loading and more. -->
    <script src="jspm_packages/system.js"></script>

    <!-- Enable loading dependencies
         that were installed with jspm. -->
    <script src="config.js"></script>

    <!-- Load the main JavaScript file
         that can import others. In this
         example, main.js is in same directory.
         Can also specify a relative directory path. -->
    <script>System.import('main');</script>
  </body>
</html>
```

index.html



```
import $ from 'jquery';
import * as strUtil from './str-util';

$('#content').text('initials are ' +
  strUtil.initials(
    'Richard Mark Volkmann')); main.js
```

```
export function initials(text) {
  return text.split(' ').
    map(word => word[0]).
    join('');
} str-util.js
```

jspm Example #2

jspm install bootstrap

adds Bootstrap and more jQuery

```
<!DOCTYPE html>
<html>
  <head>
    <title>jspm demo</title>
    <meta charset="utf-8">
    <link rel="stylesheet" href="main.css">
    <script src="jspm_packages/system.js"></script>
    <script src="config.js"></script>
    <script>System.import('main');</script>
  </head>
  <body>
    <label>Name</label>
    <input id="name-input"
      class="form-control"
      value="Richard Mark Volkmann">
    <button id="get-initials-btn"
      class="btn btn-default">
      Get Initials
    </button>
    <div id="content"></div>
  </body>
</html>
```

index.html

```
body {
  display: none;
  padding: 10px;
}

input.form-control {
  display: inline-block;
  vertical-align: middle;
  width: 180px;
}
```

main.css

```
import 'bootstrap';
import $ from 'jquery';
import * as strUtil from './str-util';

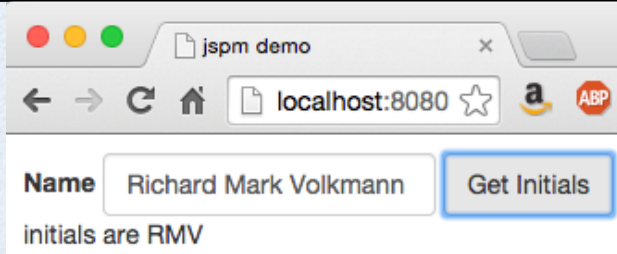
$('#get-initials-btn').click(() => {
  let name = $('#name-input').val();
  let initials = strUtil.initials(name);
  $('#content').text(
    'initials are ' + initials);
});

$('body').show();
```

main.js

```
export function initials(text) {
  return text.split(' ').
    map(word => word[0]).
    join('');
}
```

str-util.js



Iterators and Iterables

- Iterators are objects that can visit elements in a sequence
 - not created with a custom class; can be `Object`
 - have a `next` method and optional `return` and `throw` methods
 - described on next slide
- Iterables are objects that have a method whose name is the value of `Symbol.iterator`
 - this method returns an iterator

Iterator Methods

- **next** method
 - gets next value in sequence
 - takes optional argument, but not on first call
 - specifies value that the `yield` hit in this call will return at the start of processing for the next call
 - returns a **new object** with `value` and `done` properties
 - `done` will be true if end of sequence has been reached; can omit if false
 - when `done` is true, `value` is not valid; typically `undefined`; can omit
- **return** method (optional)
 - called if iteration ends before iterator returns `done: true`
 - can end iteration with `break`, `return`, `throw`, and `continue` (with label of outer loop; rarely used)
 - allows iterator to clean up (ex. close files)
- **throw** method (optional)
 - takes error argument and throws it inside generator function that created the iterator
 - can catch inside generator function

Why return a new object from `next` method instead of returning the same object with modified `value` and `done` properties?

It is possible for an iterator to be used by more than one consumer and those consumers could access the object returned by `next` asynchronously. If each call doesn't return a new object, its properties could be modified after the object is received, but before it checks the properties. While this is a rare situation, implementers of iterators can't be sure how they will be used.

`yield` and generators will be discussed soon

Iterable Objects ...

- Objects from these builtin classes are iterable
 - **Array** - over elements
 - **Map** - over key/value pairs as [*key*, *value*]
 - **Set** - over elements
 - DOM **NodeList** - over **Node** objects (coming soon)
- Primitive strings are iterable
 - over Unicode code points
- These methods on **Array** (including typed arrays), **Map**, and **Set** return an iterable
 - **entries** - over key/value pairs as [*key*, *value*]
 - **keys** - over keys
 - **values** - over values
- Custom objects can be made iterable
 - by adding **Symbol.iterator** method

for arrays, keys are indices;
for sets, keys are same as values

... Iterable Objects

- To get an iterable representation of an array-like object
 - `let iterable = Array.from(arrayLike)`
- **Ordinary objects** such as those created from object literals are **not iterable**
 - when this is desired, use new `Map` class instead **or** write a function like the following

```
function objectEntries(obj) {
  let index = 0;
  let keys = Reflect.ownKeys(obj); // gets both string and symbol keys
  return { // note how the iterable and iterator can be same object
    [Symbol.iterator]() { return this; },
    next() {
      if (index === keys.length) return {done: true};
      let k = keys[index++], v = obj[k];
      return {value: [k, v]};
    }
  };
}

let obj = {foo: 1, bar: 2, baz: 3};
for (let [k, v] of objectEntries(obj)) {
  console.log(k, 'is', v);
}
```

Iterable Consumers

- **for-of** loop
 - `for (let value of someIterable) { ... } // iterates over all values`
- **spread operator**
 - can add all values from an iterable into a new array
 - `let arr = [firstElem, ...someIterable, lastElem];`
 - can use all values from iterable as arguments to a function, method, or constructor call
 - `someFunction(firstArg, ...someIterable, lastArg);`
- **destructuring to an array**
 - `let [a, b, c] = someIterable; // gets first three values`
- **Map** constructor takes an iterable over key/value pairs
- **Set** constructor takes an iterable over elements
- **Promise** methods **all** and **race** take an iterable over promises
- In a generator, **yield*** yields all values in an iterable one at a time

Iterator Example #1

```
let fibonacci = {  
  [Symbol.iterator]() {  
    let prev = 0, curr = 1;  
    return {  
      next() {  
        [prev, curr] = [curr, prev + curr];  
        return {value: curr};  
      }  
    };  
  }  
};  
  
for (let n of fibonacci) {  
  if (n > 100) break;  
  console.log(n);  
}
```

iterators can also be implemented with generators - see slide 89

1
2
3
5
8
13
21
34
55
89

stops iterating when done is true which never happens in this example

Iterator Example #2

```
let arr = [1, 2, 3, 5, 6, 8, 11];
let isOdd = n => n % 2 === 1;

// This is less efficient than using an iterator because
// the Array filter method builds a new array and
// iteration cannot begin until that completes.
arr.filter(isOdd).forEach(n => console.log(n)); // 1 3 5 11

// This is more efficient, but requires more code.
function getFilterIterator(arr, filter) {
  let index = 0;
  return {
    [Symbol.iterator] = () => ({
      next() {
        while (true) {
          if (index >= arr.length) return {done: true};
          let value = arr[index++];
          if (filter(value)) return {value};
        }
      }
    })
  };
}

for (let v of getFilterIterator(arr, isOdd)) {
  console.log(v); // 1 3 5 11
}
```

Generators

- **Generator functions**
 - implicitly return a **generator** which is a special kind of **iterator**
 - have multiple return points, each specified using `yield` keyword
 - each `yield` is hit in a separate call to the iterator `next` method
- Can obtain values from a sequence one at a time
 - supports lazy evaluation and infinite sequences
- Defined with `function* name(params) { code }`
 - `code` uses `yield` keyword to return each value in sequence, often inside a loop
 - ends when generator function exits
 - can exit using `return` keyword; value returned is not yielded
- Can create generator methods in class definitions
 - preceded method name with `*`
 - ex. to make instances iterable, `* [Symbol.iterator]() { ... }`

Steps to Use Generators

- 1) Call generator function to obtain generator
- 2) Call generator `next` method to request next value
 - optionally pass a value that iterator can use to compute the subsequent value
 - after iterator “yields” next value, its code is “suspended” until next request
- 3) Process value
- 4) Repeat from step 2

When an iterator is used in a `for-of` loop it performs steps 2 and 4. Step 3 goes in loop body.

```
for (let v of someGenerator()) {  
  // process v  
}
```


Generator `yield`

- To return a “normal” value
 - `yield value;`

```
function* fibonacci() {  
  let [prev, curr] = [0, 1];  
  while (true) {  
    [prev, curr] = [curr, prev + curr];  
    yield curr;  
  }  
}  
  
for (let value of fibonacci()) {  
  if (value > 100) break;  
  console.log(value);  
}
```

compare to
slide 85

```
1 // Iterables can be  
2 // implemented with generators.  
3 let fib = {  
4   * [Symbol.iterator]() {  
5     let [prev, curr] = [0, 1];  
6     while (true) {  
7       [prev, curr] = [curr, prev + curr];  
8       yield curr;  
9     }  
10  }  
11 };  
12  
13 for (let n of fib) {  
14   if (n > 100) break;  
15   console.log(n);  
16 }  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
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85  
86  
87  
88  
89
```

- To yield each value returned by an iterable one at a time
 - `yield* some-iterable;`
 - can obtain an iterable by calling another generator function - `otherGenerator(params)` ;
 - not commonly used

More Generator Examples

```
function* gen2(v) {  
  try {  
    v = yield 'foo' + v;  
    v = yield 'bar' + v;  
    yield 'baz' + v;  
  } catch (e) {  
    console.error('caught', e);  
  }  
}
```

```
let iter = gen2(1); // can pass value to generator function,  
let result = iter.next(); // but can't pass in first call to next  
console.log(result.value); // foo1; result.done is false
```

```
result = iter.next(2);  
console.log(result.value); // bar2; result.done is false
```

```
//iter.throw('stop now'); // triggers catch in gen2
```

```
result = iter.next(3);  
console.log(result.value); // baz3; result.done is false
```

```
result = iter.next(4);  
console.log(result.done ? 'done' : result.value); // done
```

```
function* gen1() {  
  yield 'foo';  
  yield 'bar';  
  yield 'baz';  
}  
  
for (let value of gen1()) {  
  console.log(value);  
}
```

Generators For Async ...

workflow.js

```
function double(n) {  
  return new Promise(resolve => resolve(n * 2));  
}
```

multiplies a given number
by 2 asynchronously

```
function triple(n) {  
  return new Promise(resolve => resolve(n * 3));  
}
```

multiplies a given number
by 3 asynchronously

```
function badOp(n) {  
  return new Promise((resolve, reject) => reject('I failed!'));  
}
```

called on
next slide

```
function async(generatorFn) {  
  let iter = generatorFn();  
  function success(result) {  
    let next = iter.next(result);  
    // next.value is a promise  
    // next.done will be true if iter.next is called after  
    // the last yield in workflow (on next slide) has run.  
    if (!next.done) next.value.then(success, failure);  
  }  
  function failure(err) {  
    let next = iter.throw(err);  
    // next.value is a promise  
    // next.done will be false if the error was caught and handled.  
    if (!next.done) next.value.then(success, failure);  
  }  
  success();  
}
```

The magic! This obtains and waits for each of the promises
that are yielded by the specified generator function.
It is a utility method that would only be written once.

BUT DON'T DO THIS!
See `async` and `await`
keywords ahead.

compare to
slide 98

... Generators for Async

Call multiple asynchronous functions in series in a way that makes them appear to be synchronous. This avoids writing code in the pyramid of doom style.

```
async(function* () { // passing a generator
  let n = 1;
  try {
    n = yield double(n);
    n = yield triple(n);
    //n = yield badOp(n);
    console.log('n =', n); // 6
  } catch (e) {
    // To see this happen, uncomment yield of badOp.
    console.error('error:', e);
  }
});
```

These yield promises that the `async` function waits on to be resolved or rejected.

This can be simplified with new ES7 keywords!

Proxies ...

- Can intercept all operations whose names match functions on the **Reflect** object
 - see slide 51
 - can provide additional or alternate functionality
- Uses new **Proxy** class
 - constructor takes "target" (the object for which operations are to be intercepted) and "handler" (an object that defines alternate handling)
- Must use proxy object instead of target object or interceptions won't occur!
- Methods called on proxy that aren't defined there are forwarded to the target object
- Can create proxies that can be later turned off (revoked)
 - after being revoked, calls on proxies object are just forwarded to target
- Proxies can be the prototype of other objects
- **Support** - currently only Firefox; no transpilers

... Proxies

```
var obj = {  
  p1: 'some value',  
  m1: () => 'm1 result',  
  m2: () => 'm2 result'  
};
```

At the time this was written, only Firefox supported proxies. However, there were other ES6 features it did not yet support such as "let" and enhanced object literals.

```
var proxy = new Proxy(obj, {  
  get: (target, key) => {  
    console.log('intercepted get for key =', key);  
    var value = target[key];  
    return value === undefined ? () => 'missing method ' + key :  
      typeof value === 'string' ? value.toUpperCase() :  
      value;  
  },  
  set: (target, key, value) => {  
    console.log('intercepted set for key =', key);  
    target[key] = value;  
  }  
});
```

```
// Replace a method on obj with a proxy for it.  
obj.m1 = new Proxy(obj.m1, {  
  apply: (fn, target, args) => {  
    console.log('intercepted call to function', fn);  
    var result = fn.apply(target, args);  
    return typeof result === 'string' ? result.toUpperCase() : value;  
  }  
});
```

This works because functions are objects.

```
proxy.p1 = 'other value';  
console.log('proxy.p1 =', proxy.p1);  
console.log('obj.p1 =', obj.p1);  
  
console.log('proxy.m1() =', proxy.m1()); // has a proxy  
console.log('proxy.m2() =', proxy.m2()); // doesn't have a proxy  
  
console.log(proxy.makeMeUpOnTheFly());
```

Proxies **can't distinguish** between gets for **property lookup** and gets for **method calls**, so "method missing" can only be implemented if it can be assumed that all missing property lookups should provide a method. It could only supply methods for key names that match a certain pattern.

Output

```
intercepted set for key = p1  
intercepted get for key = p1  
proxy.p1 = OTHER VALUE  
obj.p1 = other value  
  
intercepted get for key = m1  
intercepted call to function function obj.m1()  
proxy.m1() = M1 RESULT  
  
intercepted get for key = m2  
proxy.m2() = m2 result  
  
intercepted get for key = makeMeUpOnTheFly  
missing method makeMeUpOnTheFly
```

Tail Call Optimization

- Makes it possible to avoid growing the call stack when making recursive calls or invoking callback functions

continuation passing style (CPS)

- otherwise could exceed maximum call stack allowed
- alternative to recursion is using loops

- Possible when the last operation in a function is a function call

```
function fac(n, acc) {
  return n == 0 ? acc : fac(n - 1, acc * n);
}
function factorial(n) {
  return fac(n, 1);
}
```

- translates to

```
// This version can't use TCO because
// multiplication occurs AFTER the recursive call.
function factorial(n) {
  return n <= 1 ? n : n * factorial(n - 1);
}
```

- Support - currently only Babel; no browsers

```
"use strict";

function fac(_x, _x2) {
  var _again = true;
  _function: while (_again) {
    _again = false;
    var n = _x,
        acc = _x2;
    if (n == 0) {
      return acc;
    } else {
      _x = n - 1;
      _x2 = acc * n;
      _again = true;
      continue _function;
    }
  }
}

function factorial(n) {
  return fac(n, 1);
}
```

a label

why not drop the
_again flag, label,
and continue and
change the loop
condition to true?

What's Next?

- The next version is always referred to as "JS-next"
- Currently that is ES7
- Will include
 - `async` and `await` keywords
 - type annotations
 - new `Object` instance method `observe`
 - array comprehensions
 - generator comprehensions
 - value objects - immutable datatypes for representing many kinds of numbers
 - more

async and await ...

- Keywords to be added **in ES7**
 - already implemented in Traceur as an experimental feature
 - JSHint doesn't recognize these yet
- Hide use of generators for managing async operations, simplifying code
- Replace use of `yield` keyword with `await` keyword to wait for a value to be returned asynchronously
 - `await` can be called on any function
 - not required to be marked as `async` or return a `Promise`
- Mark functions that use `await` with `async` keyword
- Works in Traceur and Babel now in experimental mode

... async and await

```
function sleep(ms) {  
  return new Promise(resolve => {  
    setTimeout(resolve, ms);  
  });  
}
```

compare to
slides 91-92

Call multiple asynchronous functions in series in a way that makes them appear to be synchronous. This avoids writing code in the pyramid of doom style.

```
async function double(n) {  
  await sleep(50);  
  return n * 2;  
}
```

async function

```
function triple(n) {  
  return new Promise(resolve => resolve(n * 3));  
}
```

function that returns a promise

```
function quadruple(n) {  
  return n * 4;  
}
```

"normal" function

```
function badOp() {  
  return new Promise(  
    (resolve, reject) => reject('I failed!'));  
}
```

```
async function work() {  
  let n = 1;  
  try {  
    n = await double(n);  
    n = await triple(n);  
    //n = await badOp(n);  
    n = await quadruple(n);  
    console.log('n =', n); // 24  
  } catch (e) {  
    // To see this happen,  
    // uncomment await of badOp.  
    console.error('error:', e);  
  }  
}  
  
work();
```

Type Annotations ...

- Optional type annotations for variables, properties, function parameters, and function return types
 - current syntax: *thing-to-annotate: type-expression*
 - details of syntax are still being determined
 - if not specified, can hold any kind of value
- Will provide run-time type checking
- Can specify builtin types and names of custom classes
- Types are first-class values
 - can be stored in variables and passed to functions
- Builtin types: **boolean, number, string, void, any**
- To use in Traceur, enable experimental mode
 - supports specifying types, but doesn't enforce them yet
- See <http://wiki.ecmascript.org/doku.php?id=strawman:types&s=types>

... Type Annotations

```
function initials(name:string):string {
  return name.split(' ').map(part => part.charAt(0)).join('');
}

function isFullName(name:string):boolean {
  return name.split(' ').length >= 3;
}

let name = 'Richard Mark Volkmann';
//let name = 'Mark Volkmann';
console.log('initials are', initials(name)); // RMV
console.log('full name?', isFullName(name)); // true
```

```
class Point {
  constructor(x:number, y:number) {
    this.x = x;
    this.y = y;
  }

  distanceFrom(point:Point) {
    return Math.hypot(this.x - point.x, this.y - point.y);
  }
}

let p1 = new Point(1, 2);
let p2 = new Point(4, 6);
console.log('distance =', p1.distanceFrom(p2));
```

Summary

- Which features of ES6 should you start using today?
- I recommend choosing those in the intersection of the set of features supported by Traceur and JSHint
- Includes at least these
 - arrow functions
 - block scope (`const`, `let`, and functions)
 - classes
 - default parameters
 - destructuring
 - enhanced object literals
 - `for-of` loops
 - iterators
 - generators
 - modules
 - promises
 - rest parameters
 - spread operator
 - template strings
 - new methods in `String` and `Object` classes