Interactive Web Programming

1st semester of 2021

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Heavily based on **Victoria Kirst** slides

Schedule

Today:

- More on callbacks
- Functional JavaScript
  - Currying
  - Closures
  - Anonymous functions

Next:

- Promises
- Fetch API

A quick note on HW2

A quick note on HW2

General stuff:

- I sent a feedback for each one of you on **sunday** at **19h30**.
- If you **didn't receive anything** from me yesterday, please, send me an email **ASAP (murilo.filho@fgv.br)**.
- Some aspects were not very clear:
  - **You should** use CSS techniques to make the page responsive.
  - The time counter **should not** be cleaned when changing a season.
- Some of you lost points on those aspects but **don't worry**!

A quick note on HW2

On the deadlines:

- If you turn **HW1** until **April 16**, you can get up to **40%** of the grade.
- If you turn **HW2** until **April 16**, you can get up to **70%** of the grade.
- **April 16** will be the **last day** for the first block of homework to compose **A1 grade**: HW1, HW2, and HW3.

ATTENTION:

- If you take all feedback from yesterday and fix everything by **April 16**, you can still earn a **10**!!!
- For that you **MUST** fix everything you can, answer the google forms and send me an email confirming you want a new evaluation.

Callbacks

A real example: Callbacks

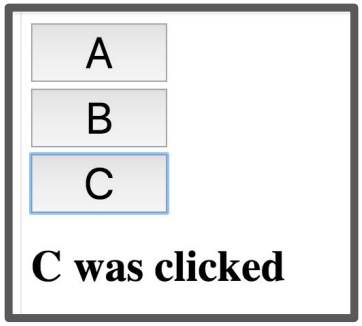
Another way we can communicate between classes is through callback functions:

- **Callback**: A function that's passed as a parameter to another function, usually in response to something.

Recall: Button example

Menu:

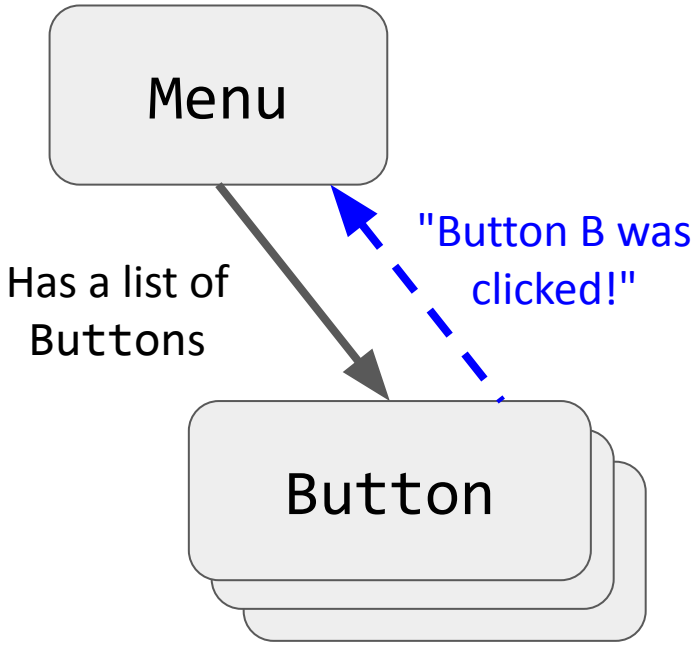
- Has an array of `Buttons`
- Also updates the <h1> with what was clicked



Button:

- Notifies Menu when clicked, so that Menu can update the <h1>

[Solution with Custom Events]



```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A'),
      new Button(this.buttonContainer, 'B'),
      new Button(this.buttonContainer, 'C')
    ];

    document.addEventListener('button-clicked', this.showButtonClicked);
  }

  showButtonClicked(event) {
    this.statusBar.textContent = event.detail.buttonName + ' was clicked';
  }
}
```

Custom Events: Menu **listens** for a `'button-clicked'` event

```
class Button {
  constructor(containerElement, text) {
    this.containerElement = containerElement;
    this.text = text;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    const eventInfo = {
      buttonName: this.text
    };
    document.dispatchEvent(
        new CustomEvent('button-clicked', { detail: eventInfo }));
  }
}
```

Custom Events: `Button` **dispatches** a `'button-clicked'` event, with information on what was clicked

How would we implement
the same thing with callbacks?

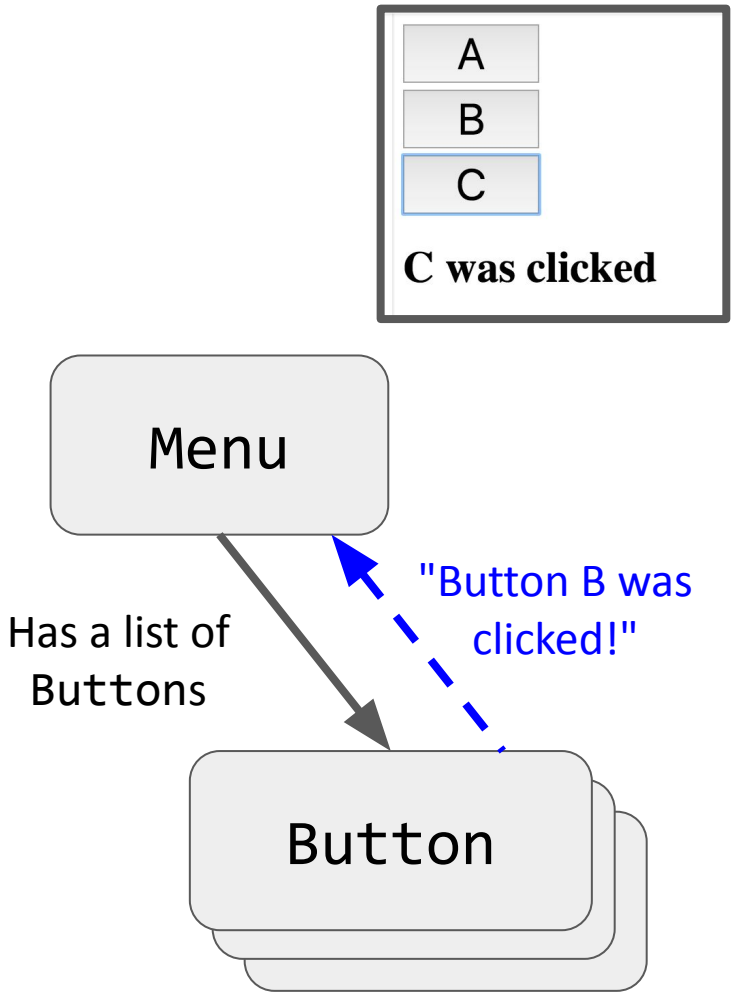
Callback solution

Button:

- Takes a **function parameter** (callback) in the constructor
- Saves this parameter as a field
- Invokes the saved callback function when clicked

`Menu`:

- Passes `showButtonClicked` method as parameter in `Button` constructor



```
class Button {
  constructor(containerElement, text) {
    this.containerElement = containerElement;
    this.text = text;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    console.log('clicked: ' + this.text);
  }
}
```

Callback Sender Strategy: Add an `onClickedCallback` function parameter to the `Button` constructor, save it in field, and invoke it `onClick`.

```
class Button {
  constructor(containerElement, text, onClickedCallback) {
    this.containerElement = containerElement;
    this.text = text;
    this.onClickedCallback = onClickedCallback;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    this.onClickedCallback(this.text);
  }
}
```

```
class Button {
  constructor(containerElement, text, onClickedCallback) {
    this.containerElement = containerElement;
    this.text = text;
    this.onClickedCallback = onClickedCallback;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    this.onClickedCallback(this.text);
  }
}
```

Button constructor takes an onClickedCallback function parameter, which is saves in a field of the same name

```
class Button {
  constructor(containerElement, text, onClickedCallback) {
    this.containerElement = containerElement;
    this.text = text;
    this.onClickedCallback = onClickedCallback;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    this.onClickedCallback(this.text);
  }
}
```

Invoke the saved callback function when clicked.

```
class Button {
  constructor(containerElement, text, onClickedCallback) {
    this.containerElement = containerElement;
    this.text = text;
    this.onClickedCallback = onClickedCallback;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    this.onClickedCallback(this.text);
  }
}
```

You can send whatever parameter(s) you'd like in the callback function.

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.buttons = [
      new Button(this.buttonContainer, 'A'),
      new Button(this.buttonContainer, 'B'),
      new Button(this.buttonContainer, 'C')
    ];
  }
}
```

Callback Receiver Strategy: Add a method to be called when a button is clicked and pass it to the constructor of `Button`

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A', this.showButtonClicked),
      new Button(this.buttonContainer, 'B', this.showButtonClicked),
      new Button(this.buttonContainer, 'C', this.showButtonClicked)
    ];
  }

  showButtonClicked(buttonName) {
    this.statusBar.textContent = buttonName + ' was clicked';
  }
}
```

Add the `showButtonClicked` method,
which should be called when the button is clicked.

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A', this.showButtonClicked),
      new Button(this.buttonContainer, 'B', this.showButtonClicked),
      new Button(this.buttonContainer, 'C', this.showButtonClicked)
    ];
  }

  showButtonClicked(buttonName) {
    this.statusBar.textContent = buttonName + ' was clicked';
  }
}
```

Add the `showButtonClicked` method,
which should be called when the button is clicked.

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A', this.showButtonClicked),
      new Button(this.buttonContainer, 'B', this.showButtonClicked),
      new Button(this.buttonContainer, 'C', this.showButtonClicked)
    ];
  }

  showButtonClicked(buttonName) {
    this.statusBar.textContent = buttonName + ' was clicked';
  }
}
```

Note that we still have to bind `showButtonClicked`, even though it won't be invoked as a result of a DOM event.

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A', this.showButtonClicked),
      new Button(this.buttonContainer, 'B', this.showButtonClicked),
      new Button(this.buttonContainer, 'C', this.showButtonClicked)
    ];
  }

  showButtonClicked(buttonName) {
    this.statusBar.textContent = buttonName + ' was clicked';
  }
}
```

Pass the `showButtonClicked` method
to the constructor of `Button`

Button example solution

Solution with Callbacks

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A', this.showButtonClicked),
      new Button(this.buttonContainer, 'B', this.showButtonClicked),
      new Button(this.buttonContainer, 'C', this.showButtonClicked)
    ];
  }

  showButtonClicked(buttonName) {
    this.statusBar.textContent = buttonName + ' was clicked';
  }
}
```

Q: Why did we have to bind `showButtonClick`?

`this` in a method

`this` in different contexts

`this` in a constructor:

- `this` is set to the new object being created

`this` in a function firing in response to a DOM event:

- `this` is set to the DOM element to which the event handler was attached

`this` being called as a method on an object:

- `this` is set to the that is calling the method, or the object on which the method is called.

(all values of `this`)

```
class Button {
  constructor(containerElement, text, onClickedCallback) {
    this.containerElement = containerElement;
    this.text = text;
    this.onClickedCallback = onClickedCallback;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    this.onClickedCallback(this.text);
  }
}
```

When `Button` is constructed, `showButtonClicked` is being saved in `Button`'s `onClickedCallback` field

```
class Button {
  constructor(containerElement, text, onClickedCallback) {
    this.containerElement = containerElement;
    this.text = text;
    this.onClickedCallback = onClickedCallback;

    this.onClick = this.onClick.bind(this);

    const button = document.createElement('button');
    button.textContent = text;
    button.addEventListener('click', this.onClick);
    this.containerElement.append(button);
  }

  onClick() {
    this.onClickedCallback(this.text);
  }
}
```

Button is the object that ultimately calls the showButtonClicked function.

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    // this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A', this.showButtonClicked),
      new Button(this.buttonContainer, 'B', this.showButtonClicked),
      new Button(this.buttonContainer, 'C', this.showButtonClicked)
    ];
  }

  showButtonClicked(buttonName) {
    console.log(this);
    this.statusBar.textContent = buttonName + ' was clicked';
  }
}
```

Without the call to `bind`, `this` in `showButtonClicked` is `Button`, and this will result in a JS error when we try to refer to `this.statusBar.textContent` (CodePen)

```
class Menu {
  constructor() {
    this.buttonContainer = document.querySelector('#menu');
    this.statusBar = document.querySelector('#status-bar');

    this.showButtonClicked = this.showButtonClicked.bind(this);

    this.buttons = [
      new Button(this.buttonContainer, 'A', this.showButtonClicked),
      new Button(this.buttonContainer, 'B', this.showButtonClicked),
      new Button(this.buttonContainer, 'C', this.showButtonClicked)
    ];
  }

  showButtonClicked(buttonName) {
    this.statusBar.textContent = buttonName + ' was clicked';
  }
}
```

But with the call to bind, `this` in `showButtonClicked` is the Menu, which is the behavior we want. (CodePen)

One more look at `bind`

Objects in JS

Objects in JavaScript are sets of property-value pairs:

```
const bear = {
  name: 'Ice Bear',
  hobbies: ['knitting', 'cooking', 'dancing']
};
```

Classes in JS

```
class Playlist {
  constructor(name) {
    this.playlistName = name;
    this.songs = [];
  }

  addSong(songName) {
    this.songs.push(songName);
  }
}

const playlist = new Playlist('More Life');
playlist.addSong('Passionfruit');
```

Classes in JavaScript produce **objects** through new. (CodePen)

Classes in JS

```
class Playlist {
  constructor(name) {
    this.playlistName = name;
    this.songs = [];
  }

  addSong(songName) {
    this.songs.push(songName);
  }
}

const playlist = new Playlist('More Life');
playlist.addSong('Passionfruit');
```

Q: Are the objects created from classes also sets of property-value pairs?

Classes and objects

```
const playlist = new Playlist('More Life');
```

A: Yes. The `playlist` object created by the constructor essentially* looks like this:

```
{
  playlistName: 'More Life',
  songs: [],
  addSong: function(songName) {
    this.songs.push(songName);
  }
}
```

Technically addSong (and the constructor function) is defined in the prototype of the playlist object, but we haven't talked about prototypes and probably won't talk about prototypes until the end of the quarter.

Classes and objects

```
const playlist = new Playlist('More Life');
```

In JavaScript, a **method** of an object is just a **property** whose value is of `Function` type.

```
{
  playlistName: 'More Life',
  songs: [],
  addSong: function(songName) {
    this.songs.push(songName);
  }
}
```

Classes and objects

```
const playlist = new Playlist('More Life');
```

In JavaScript, a **method** of an object is just a **property** whose value is of `Function` type.

```
{
  playlistName: 'More Life',
  songs: [],
  addSong: function(songName) {
    this.songs.push(songName);
  }
}
```

And just like any other Object property, the value of that method can be changed.

Rewriting a function

```
class Playlist {
  constructor(name) {
    this.playlistName = name;
    this.songs = [];
  }

  addSong(songName) {
    this.songs.push(songName);
  }
}

const playlist = new Playlist('More Life');
playlist.addSong = function(songName) {
  console.log("Nah");
};

playlist.addSong('Passionfruit');
console.log(playlist);
```

Q: What is the output of this code?

CodePen

Rewriting a function

```
class Playlist {
  constructor(name) {
    this.playlistName = name;
    this.songs = [];
  }

  addSong(songName) {
    this.songs.push(songName);
  }
}

const playlist = new Playlist('More Life');
playlist.addSong = function(songName) {
  console.log("Nah");
};

playlist.addSong('Passionfruit');
console.log(playlist);
```

Console

```
"Nah"
```

```
▼ Object {
  ▶   addSong: function (songName) {↔},
      playlistName: "More Life",
      songs: []
  }
```

When would you ever want to rewrite the definition of a method?!

`bind` in classes

```
constructor() {
  const someValue = this;
  this.onClick = this.onClick.bind(someValue);
}
```

The code in purple is saying:

- Make a copy of `onClick`, which will be the exact same as `onClick` except `this` in `onClick` is always set to the `someValue`

`bind` in classes

```
constructor() {
  const someValue = this;
  this.onClick = this.onClick.bind(someValue);
}
```

The code in purple is **rewriting the `onClick` property** of the object:

- Assign the value of the **`onClick`** property: set it to the new function returned by the call to `bind`

Practical Functional JavaScript

Functional programming

We are going to cover some topics that are fundamental to a programming paradigm called **functional programming**.

Pure functional programming is pretty extreme:

- Everything in your code is either a function or an expression
- There are no statements
- There is no state:
  - No variables, fields, objects, etc

Comes from the idea of treating a computer program as a mathematical function

Functional programming

This is a code snippet from Scheme, a functional programming language:

```
(define (sum row)
  (let loop ((row row) (result '()))
    (if (= (length row) 1)
        (reverse result)
        (loop (cdr row)
              (cons (+ (first row) (second row))
                    result)))))
```

Everything is a function or the result of a function call.

Practical FP in JS

Most software is **not** built using a pure functional programming paradigm, so we won't be covering it.

But there are some ideas from functional programming that are immensely useful:

- First-class functions (functions as objects)
- **Currying**
- **Closures**
- **Anonymous functions** / lambdas / function literals

Why FP matters

Why should we learn about this other programming paradigm?

- There are **ideas you can express more clearly** and concisely with functional programming.
- There are **problems you can solve much more easily** with functional programming.
- *(very practically)* You will see JavaScript code in the wild that uses functional programing and the code will be indecipherable if you don't learn it.
- *(very practically)* Functional programming is trendy and so useful that C++ and Java added support for a few critical FP concepts (lambdas/closures) in the past few years.

First-class functions

Functions in JavaScript are objects.

- They can be saved in variables
- They can be passed as parameters
- They have properties, like other objects
- They can be defined without an identifier

(This is also called having **first-class functions**, i.e. functions in JavaScript are "first-class" because they are treated like any other variable/object.)

Recall: Functions as parameters

We know that we can pass functions as parameters to other functions. We've already done this multiple times:

- The event handler parameter to `addEventListener`
- As a parameter for a constructor of a new object

`Array` objects also have several methods that take functions as parameters.

Example: `findIndex`

***list*.`findIndex(`*callback*`, `*thisArg*`)`:**

Returns the index of an element.

callback is a function with the following parameters:

- **element:** The current element being processed.
- **index:** The index of the current element being processed in the array.
- **array**: the array `findIndex` was called upon.

callback is called for every element in the array, and returns true if found, false otherwise.

thisArg is the value of `this` in ***callback***

Remove with for-loop

```
// Removes the first song in the playlist that
// matches |songName|, case insensitive.
removeSong(songName) {
  for (let i = 0; i < this.songs.length; i++) {
    const song = this.songs[i];
    if (song.toLowerCase() === songName.toLowerCase()) {
      this.songs.shift(i, 1);
      break;
    }
  }
}
```

Let's say that we added a `removeSong` method to `Playlist` (CodePen)

Remove with findIndex

```
// Removes the first song in the playlist that
// matches |songName|, case insensitive.
removeSong(songName) {
  for (let i = 0; i < this.songs.length; i++) {
    const song = this.songs[i];
    if (song.toLowerCase() === songName.toLowerCase()) {
      this.songs.shift(i, 1);
      break;
    }
  }
}
```

How would we rewrite this using `findIndex`?

[Starter CodePen]

General approach

```
doesSongTitleMatch(element, index, array) {
  // ...
  // return true if the song title matches
  // false otherwise
}

removeSong(songName) {
  const index = this.songs.findIndex(doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

We want to do something like this...

General approach

```
doesSongTitleMatch(element, index, array) {
  // how do we get songName?
  return element === songName; // DOESN'T WORK
}

removeSong(songName) {
  const index = this.songs.findIndex(doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

But the problem is that we want to pass `songName` into the `doesSongTitleMatch` function somehow.

General approach

```
doesSongTitleMatch(element, index, array) {
  // how do we get songName?
  return element === songName; // DOESN'T WORK
}

removeSong(songName) {
  const index = this.songs.findIndex(doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

But the problem is that we want to pass `songName` into the `doesSongTitleMatch` function somehow.

Clunky solution: field

```
doesSongTitleMatch(element, index, array) {
  // This works but is really gross.
  return element === this.removeSongNameParameter;
}

removeSong(songName) {
  this.removeSongNameParameter = songName;
  const index = this.songs.findIndex(this.doesSongTitleMatch, this);
  this.songs.shift(index, 1);
}
```

We could save the song parameter as a field,
which the `doesSongTitleMatch` method can access…
(CodePen)

Clunky solution: field

```
doesSongTitleMatch(element, index, array) {
  // This works but is really gross.
  return element === this.removeSongNameParameter;
}

removeSong(songName) {
  this.removeSongNameParameter = songName;
  const index = this.songs.findIndex(this.doesSongTitleMatch, this);
  this.songs.shift(index, 1);
}
```

But then you have this weird `removeSongNameParameter` field that is only valid in between these method calls.

(CodePen)

Add a parameter?

```
doesSongTitleMatch(element, index, array) {
  // How can we get |songName| here?
  return element === songName; // DOEN'T WORK
}

removeSong(songName) {
  const index = this.songs.findIndex(this.doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

We really want to pass the `songName` value from `removeSong` to `doesSongTitleMatch` ...

Add a parameter?

```
doesSongTitleMatch(element, index, array) {
  // How can we get |songName| here?
  return element === songName; // DOEN'T WORK
}

removeSong(songName) {
  const index = this.songs.findIndex(this.doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

But the callback for `findIndex` expects 3 specific parameters, and we can't somehow add `songName`.

One solution: new function

We can do this (CodePen):

```
createMatchFunction(songName) {
  const findIndexFunction = function (element, index, array) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  return findIndexFunction;
}

removeSong(songName) {
  const matchFunction = this.createMatchFunction(songName);
  const index = this.songs.findIndex(matchFunction);
  this.songs.shift(index, 1);
}
```

One solution: new function

We can do this (CodePen):

```
createMatchFunction(songName) {
  const findIndexFunction = function (element, index, array) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  return findIndexFunction;
}

removeSong(songName) {
  const matchFunction = this.createMatchFunction(songName);
  const index = this.songs.findIndex(matchFunction);
  this.songs.shift(index, 1);
}
```

??????

Creating functions within functions

Functions that create functions

In JavaScript, we can **create** functions from within functions (CodePen).

```
function printMessage(birthYear) {
  function getLabel(age) {
    if (age < 2) {
      return "baby";
    }
    if (age < 4) {
      return "toddler";
    }
    if (age < 13) {
      return "kid";
    }
    if (age < 20) {
      return "teenager";
    }
    return "grown-up";
  }

  const ageThisYear = 2017 - birthYear;
  const label = getLabel(ageThisYear);
  console.log('You are a ' + label + ' this year.');
}

printMessage(2005);
```

Functions that create functions

In JavaScript, we can **create** functions from within functions (CodePen).

```
function printMessage(birthYear) {
  function getLabel(age) {
    if (age < 2) {
      return "baby";
    }
    if (age < 4) {
      return "toddler";
    }
    if (age < 13) {
      return "kid";
    }
    if (age < 20) {
      return "teenager";
    }
    return "grown-up";
  }
```

A function declared within a function is also known as a **closure**.

Scope of closures

```
function printMessage(birthYear) {
  if (true) {
    function getLabel(age) {
      if (age < 2) {
        return "baby";
      }
      if (age < 4) {
        return "toddler";
      }
      if (age < 13) {
        return "kid";
      }
      if (age < 20) {
        return "teenager";
      }
      return "grown-up";
    }
  }

  const ageThisYear = 2017 - birthYear;
  const label = getLabel(ageThisYear);
  console.log('You are a ' + label + ' this year.');
}
```

Functions declared with `function` (or `var`) have function scope.

- Can be referenced anywhere in the function after declaration

This example works:

Console

```
"You are a kid this year."
```

Scope of closures

```
function printMessage(birthYear) {
  function getLabel(age) {
    if (age < 2) {
      return "baby";
    }
    if (age < 4) {
      return "toddler";
    }
    if (age < 13) {
      return "kid";
    }
    if (age < 20) {
      return "teenager";
    }
    return "grown-up";
  }

  const ageThisYear = 2017 - birthYear;
  const label = getLabel(ageThisYear);
  console.log('You are a ' + label + ' this year.');
}

printMessage(2005);
const label = getLabel(8);
```

Functions declared with `function` (or `var`) have function scope.

- Cannot be referenced outside the function

This example doesn't work:

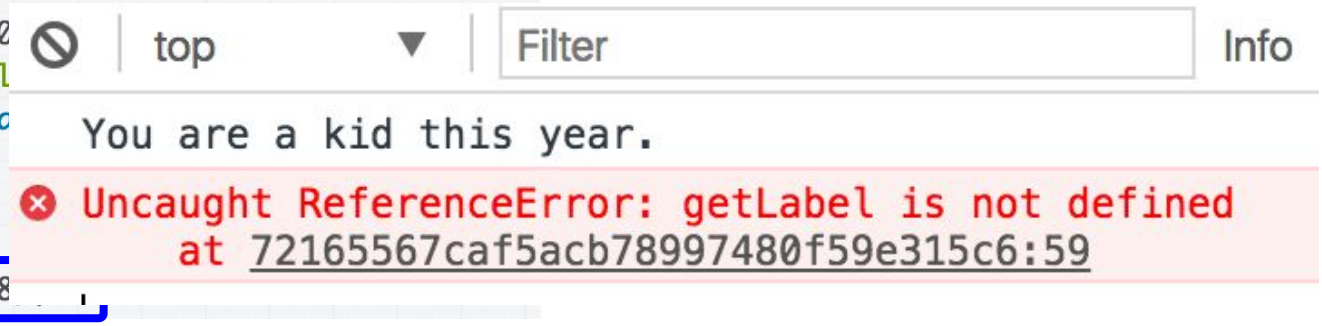
Scope of closures

```
function printMessage(birthYear) {
  function getLabel(age) {
    if (age < 2) {
      return "baby";
    }
    if (age < 4) {
      return "toddler";
    }
    if (age < 13) {
      return "kid";
    }
    if (age < 20) {
      return "teenager";
    }
    return "grown-up";
  }

  const ageThisYear = 20
  const label = getLabel
  console.log('You are a
}

printMessage(2005);
const label = getLabel(8
```

Functions declared with `function` (or `var`) have function scope.

- Cannot be referenced outside the function

This example doesn't work:



Scope of closures

```
function printMessage(birthYear) {
  if (true) {
    const getLabel = function(age) {
      if (age < 2) {
        return "baby";
      }
      if (age < 4) {
        return "toddler";
      }
      if (age < 13) {
        return "kid";
      }
      if (age < 20) {
        return "teenager";
      }
      return "grown-up";
    }
  }

  const ageThisYear = 2017 - birthYear;
  const label = getLabel(ageThisYear);
  console.log('You are a ' + label + ' this year.');
}
```

```
▶Uncaught ReferenceError: getLabel is not defined
    at printMessage (pen.js:22)
    at pen.js:26
```

Functions declared with `const` or `let` have block scope

- Cannot be referenced outside of the block.

This example doesn't work:

Functions that return functions

In JavaScript, we can **return** new functions as well.
(We kind of knew this already because `bind` returns a new function.)

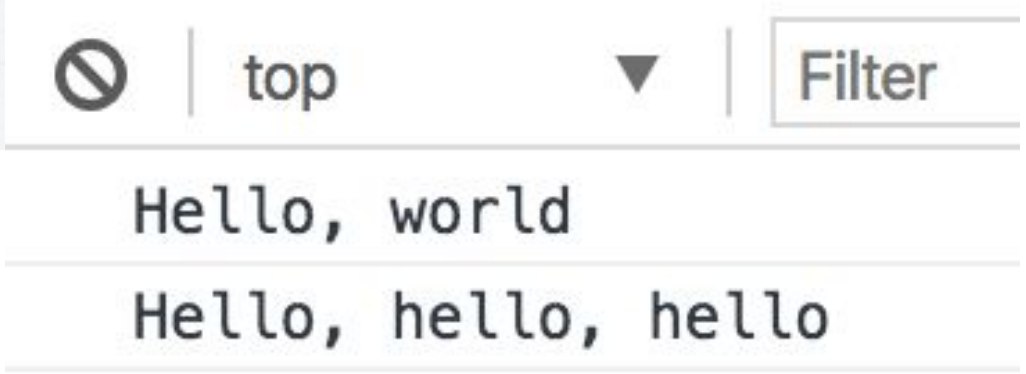
```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}

const helloWorld = makeHelloFunction('world');
const hello3 = makeHelloFunction('hello, hello');

helloWorld();
hello3();
```

CodePen

Functions that create functions

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}

const helloWorld = makeHelloFunction('world');
const hello3 = makeHelloFunction('hello, hello');

helloWorld();
hello3();
```

CodePen



Closure: an inner function

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}
```

- When you declare a function inside another function, the inner function is called a **closure**.

Closure: an inner function

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}
```

- Within a closure, you can reference variables that were declared in the outer function, and those variables **will not go away** after the outer function returns.

Functions that create functions

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}

const helloWorld = makeHelloFunction('world');
const hello3 = makeHelloFunction('hello, hello');

helloWorld();
hello3();
```

The scope of `greeting` is only in the `makeHelloFunction` function, as well as the scope of `name`...

Functions that create functions

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}

const helloWorld = makeHelloFunction('world');
const hello3 = makeHelloFunction('hello, hello');

helloWorld();
hello3();
```

But the `makeHelloFunction` function returns a reference to the function, which is an object, so the function object doesn't go away

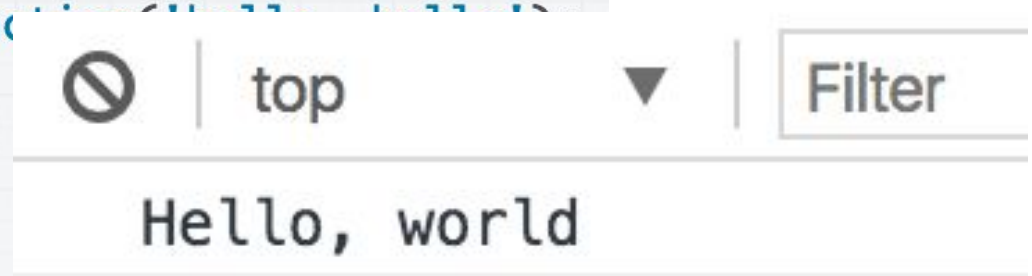
Functions that create functions

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}

const helloWorld = makeHelloFunction('world');
const hello3 = makeHelloFunction('hello, hello');

helloWorld();
hello3();
```

And the function object keeps a reference to the name parameter, so that when the created function is called...

Functions that create functions

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}

const helloWorld = makeHelloFunction('world');
const hello3 = makeHelloFunc

helloWorld();
hello3();
```



… we see that the new function returned from `makeHelloFunction` still has access to the `name` variable.

Functions that create functions

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}

const helloWorld = makeHelloFunction('world');
const hello3 = makeHelloFunction('hello, hello');

helloWorld();
hello3();
```

The idea of constructing a new function that is "partially instantiated" with arguments is called **currying**. (article)

Anonymous functions

We do not need to give an identifier to functions.

When we define a function without an identifier, we call it an **anonymous function**

- Also known as a **function literal**, or a **lambda function**

```
function makeHelloFunction(name) {
  const greeting = function() {
    console.log('Hello, ' + name);
  };
  return greeting;
}
```

Anonymous functions

We do not need to give an identifier to functions.

When we define a function without an identifier, we call it an **anonymous function**

- Also known as a **function literal**, or a **lambda function**

```
function makeHelloFunction(name) {
  return function() {
    console.log('Hello, ' + name);
  };
}
```

CodePen

Back to our Playlist

General approach

```
doesSongTitleMatch(element, index, array) {
  // how do we get songName?
  return element === songName; // DOESN'T WORK
}

removeSong(songName) {
  const index = this.songs.findIndex(doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

We want to do something like this...

General approach

```
doesSongTitleMatch(element, index, array) {
  // how do we get songName?
  return element === songName; // DOESN'T WORK
}

removeSong(songName) {
  const index = this.songs.findIndex(doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

But the problem is that we want to pass `songName` into the `doesSongTitleMatch` function somehow.

Instantiating a function...

```
doesSongTitleMatch(element, index, array) {
  // how do we get songName?
  return element === songName; // DOESN'T WORK
}

removeSong(songName) {
  const index = this.songs.findIndex(doesSongTitleMatch);
  this.songs.shift(index, 1);
}
```

We want to create a version of `doesSongTitleMatch`, with a value assigned to `songName`.

Currying

We can do this (CodePen):

```
createMatchFunction(songName) {
  const findIndexFunction = function (element, index, array) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  return findIndexFunction;
}

removeSong(songName) {
  const matchFunction = this.createMatchFunction(songName);
  const index = this.songs.findIndex(matchFunction);
  this.songs.shift(index, 1);
}
```

Currying

We've created a function whose signature matches what `findIndex` expects.

```
createMatchFunction(songName) {
  const findIndexFunction = function (element, index, array) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  return findIndexFunction;
}

removeSong(songName) {
  const matchFunction = this.createMatchFunction(songName);
  const index = this.songs.findIndex(matchFunction);
  this.songs.shift(index, 1);
}
```

Currying

We're creating this function within an outer function that takes the songName.

```
createMatchFunction(songName) {
  const findIndexFunction = function (element, index, array) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  return findIndexFunction;
}

removeSong(songName) {
  const matchFunction = this.createMatchFunction(songName);
  const index = this.songs.findIndex(matchFunction);
  this.songs.shift(index, 1);
}
```

Currying

This allows us to essentially construct a new `findIndexFunction`, with a set `songName` value.

This is called **currying**.

```
createMatchFunction(songName) {
  const findIndexFunction = function (element, index, array) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  return findIndexFunction;
}

removeSong(songName) {
  const matchFunction = this.createMatchFunction(songName);
  const index = this.songs.findIndex(matchFunction);
  this.songs.shift(index, 1);
}
```

Cleaning up `removeSong`

We can also define the `findIndexFunction` directly in `removeSong`, instead of making a separate function to create one with the right parameters (CodePen):

```
removeSong(songName) {
  const findIndexFunction = function (element, index, array) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  const index = this.songs.findIndex(findIndexFunction);
  this.songs.shift(index, 1);
}
```

Cleaning up `removeSong`

We don't need to `include` the parameters we aren't using:

```
removeSong(songName) {
  const findIndexFunction = function (element) {
    return element.toLowerCase() === songName.toLowerCase();
  }
  const index = this.songs.findIndex(findIndexFunction);
  this.songs.shift(index, 1);
}
```

Cleaning up `removeSong`

We can define the function directly in the `findIndex` parameter instead of saving it in a variable:

```
removeSong(songName) {
  const index = this.songs.findIndex(function (element) {
    return element.toLowerCase() === songName.toLowerCase();
  });
  this.songs.shift(index, 1);
}
```

Cleaning up `removeSong`

We can use the **arrow function** syntax for defining functions:

```
removeSong(songName) {
  const index = this.songs.findIndex((element) => {
    return element.toLowerCase() === songName.toLowerCase();
  });
  this.songs.shift(index, 1);
}
```

Cleaning up `removeSong`

We can use the **concise version** of the arrow function:

- You can omit the parentheses if there is only one parameter
- You can omit the curly braces if there's only one statement in the function, and it's a return statement

```
removeSong(songName) {
  const index = this.songs.findIndex(
    element => element.toLowerCase() === songName.toLowerCase());
  this.songs.shift(index, 1);
}
```

removeSong before/after

```
removeSong(songName) {
  for (let i = 0; i < this.songs.length; i++) {
    const song = this.songs[i];
    if (song.toLowerCase() === songName.toLowerCase()) {
      this.songs.shift(i, 1);
      break;
    }
  }
}
```

```
removeSong(songName) {
  const index = this.songs.findIndex(
    element => element.toLowerCase() === songName.toLowerCase());
  this.songs.shift(index, 1);
}
```

More Array functions

Function name	Description
***list*.forEach(*function*)**	Executes the provided function once for each array element. (mdn)
***list*.filter(*function*)**	Creates a new array with all elements that pass the test implemented by the provided function. (mdn)
***list*.every(*function*)**	Tests whether all elements in the array pass the test implemented by the provided function. (mdn)

All Array functions

Gotchas and style notes

Recall: Present example

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    this._openPresent = this._openPresent.bind(this);

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', this._openPresent);
    this.containerElement.append(image);
  }

  _openPresent(event) {
    const image = event.currentTarget;
    image.src = this.giftSrc;
  }
}
```

We implemented a Present class that had a separate `_openPresent` method.

[CodePen]

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', function(event) {
      const image = event.currentTarget;
      image.src = this.giftSrc;
    });
    this.containerElement.append(image);
  }
}
```

What would happen if we defined the click event handler directly in the call to `addEventListener` (CodePen)?

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', function(event) {
      const image = event.currentTarget;
      image.src = this.giftSrc;
    });
    this.containerElement.append(image);
  }
}
```

We didn't bind `this`, so we have a bug:

`this` is the `img` instead of the `Present` object.

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', (function(event) {
      const image = event.currentTarget;
      image.src = this.giftSrc;
    }).bind(this));
    this.containerElement.append(image);
  }
}
```

Fixed CodePen

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', (function(event) {
      const image = event.currentTarget;
      image.src = this.giftSrc;
    }).bind(this));
    this.containerElement.append(image);
  }
}
```

Fixed CodePen

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', event => {
      const image = event.currentTarget;
      image.src = this.giftSrc;
    });
    this.containerElement.append(image);
  }
}
```

What would happen if we defined the click event handler like this, with the arrow function instead (CodePen)?

This works! **Why?!**

([CodePen])

```
image.addEventListener('click', event => {
  const image = event.currentTarget;
  image.src = this.giftSrc;
});
```

=> versus function

When you define a function using **function syntax**:

```
const onClick = function() {
    const image = event.currentTarget;
    image.src = this.giftSrc;
};
```

this is will be dynamically assigned to a different value depending on how the function is called, like we've seen before (unless explicitly bound with bind)

=> versus function

When you define a function using **arrow syntax**:

```
const onClick = event => {
    const image = event.currentTarget;
    image.src = this.giftSrc;
};
```

this is **bound** to the value of this in its enclosing context

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', event => {
      const image = event.currentTarget;
      image.src = this.giftSrc;
    });
    this.containerElement.append(image);
  }
}
```

Since we've used the arrow function in the constructor, the `this` in the enclosing context is the new Present object.

Which is better style?

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    this._openPresent = this._openPresent.bind(this);

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', this._openPresent);
    this.containerElement.append(image);
  }

  _openPresent(event) {
    const image = event.currentTarget;
    image.src = this.giftSrc;
  }
}
```

(A) Explicit event handler

```
class Present {
  constructor(containerElement, giftSrc) {
    this.containerElement = containerElement;
    this.giftSrc = giftSrc;

    const image = document.createElement('img');
    image.src = OUTSIDE_IMAGE_URL;
    image.addEventListener('click', event => {
      const image = event.currentTarget;
      image.src = this.giftSrc;
    });
    this.containerElement.append(image);
  }
}
```

(B) Inline event handler

Callback style

```
image.addEventListener('click', this._openPresent);
```

Version A: Explicit event handler

- Pros:
  - Easier to read
  - More modular
  - Scales better to long functions, several event handlers
- Cons:
  - Because all class methods are public, it exposes the onClick function (which should be private)

Callback style

```
image.addEventListener('click', this._openPresent);
```

Version A: Explicit event handler

- Pros:
  - Easier to read
  - More modular
  - Scales better to long functions, several event handlers
- Cons:
  - Because all class methods are public, it exposes the onClick function (which should be private)
  - Need to `bind` explicitly

Callback style

```
image.addEventListener('click', event => {
  const image = event.currentTarget;
  image.src = this.giftSrc;
});
```

Version B: Inline event handler

- Pros:
  - Does not expose the event handler: function is privately encapsulated
- Cons:
  - Constructor logic has unrelated logic inside of it
  - Will get messy with lots of event handlers, long event handlers

Callback style

```
image.addEventListener('click', event => {
  const image = event.currentTarget;
  image.src = this.giftSrc;
});
```

Version B: Inline event handler

- Pros:
  - Does not expose the event handler: function is privately encapsulated
- Cons:
  - Constructor logic has un
  - Will get messy with lots event handlers

Some people strongly prefer this style because of the encapsulation aspect.

Advanced closures

```
function createFunction() {
  let x = 0;

  function inner() {
    x++;
    let y = 0;
    y++;

    console.log('x is: ' + x + ', ' + 'y is: ' + y);
  }
  return inner;
}

const functionOne = createFunction();
functionOne();
functionOne();
functionOne();
```

What's the output of this program? (CodePen)

Advanced closures

```
function createFunction() {
  let x = 0;

  function inner() {
    x++;
    let y = 0;
    y++;

    console.log('x is: ' + x + ', ' + 'y is: ' + y);
  }
  return inner;
}

const functionOne = createFunction();
functionOne();
functionOne();
functionOne();
```

Console

```
"x is: 1, y is: 1"
"x is: 2, y is: 1"
"x is: 3, y is: 1"
```

Closures

```
function createFunction() {
  let x = 0;

  function inner() {
    x++;
    let y = 0;
    y++;

    console.log('x is: ' + x + ', ' + 'y is: ' + y);
  }
  return inner;
}
```

Within a closure, you can reference variables that were declared in the outer function, and those variables **will not go away** after the outer function returns.

Closures

```
function createFunction() {
  let x = 0;

  function inner() {
    x++;
    let y = 0;
    y++;

    console.log('x is: ' + x + ', ' + 'y is: ' + y);
  }
  return inner;
}
```

The variable is not copied to the inner function; the inner function has a **reference** to the variable in the outer scope.

- See this iconic StackOverflow post to learn more

Closures

```
function createFunction() {
  let x = 0;

  function inner() {
    x++;
    let y = 0;
    y++;

    console.log('x is: ' + x + ', ' + 'y is: ' + y);
  }
  return inner;
}
```

tl;dr: Be careful with closures! For now, we are not going to be modifying outer function variables in the closure.

Review: ES6 classes

- ES6 classes mostly work the way you expect
- **`this` in a constructor:** refers to the new object being created
- **`this` outside a constructor:** refers to a different value depending on how the function is called
  - In response to a DOM event, `this` is the element that the event handler was tied to
  - When called in a method, `this` is the object that the method is called from
- **`bind`:** sets the value of `this` for a function so it does not change depending on the context

Review: Functional JavaScript

- Functions in JavaScript are **first-class citizens**:
  - Objects that can be passed as parameters
  - Can be created within functions:
    - Inner functions are called **closures**
  - Can be created without being saved to a variable
    - These are called **anonymous functions**, or function literals, or lambdas
  - Can be created and returned from functions
    - Constructing a new function that references part of the outer function's parameters is called **currying**