IN4MATX 133: User Interface Software

Lecture 5:
Javascript

Today’s goals

By the end of today, you should be able to…

- Explain the different roles HTML, CSS, and JavaScript play
- Describe how JavaScript standards evolved
- Follow JavaScript syntax for traditional programming concepts like typing, variable assignment, loops, and conditionals
- Differentiate the roles of arrays and associative arrays
- Implement functional programming concepts in JavaScript like forEach, map, and filter

Language Roles

Specify how content is rendered

Visually style content

Dynamically manipulate content

Language Roles

Markup
language

Styling
language

Programming
language

Why JavaScript?

- Make pages dynamic
- Make pages personalized
- Make pages interact with other sources, like databases and APIs

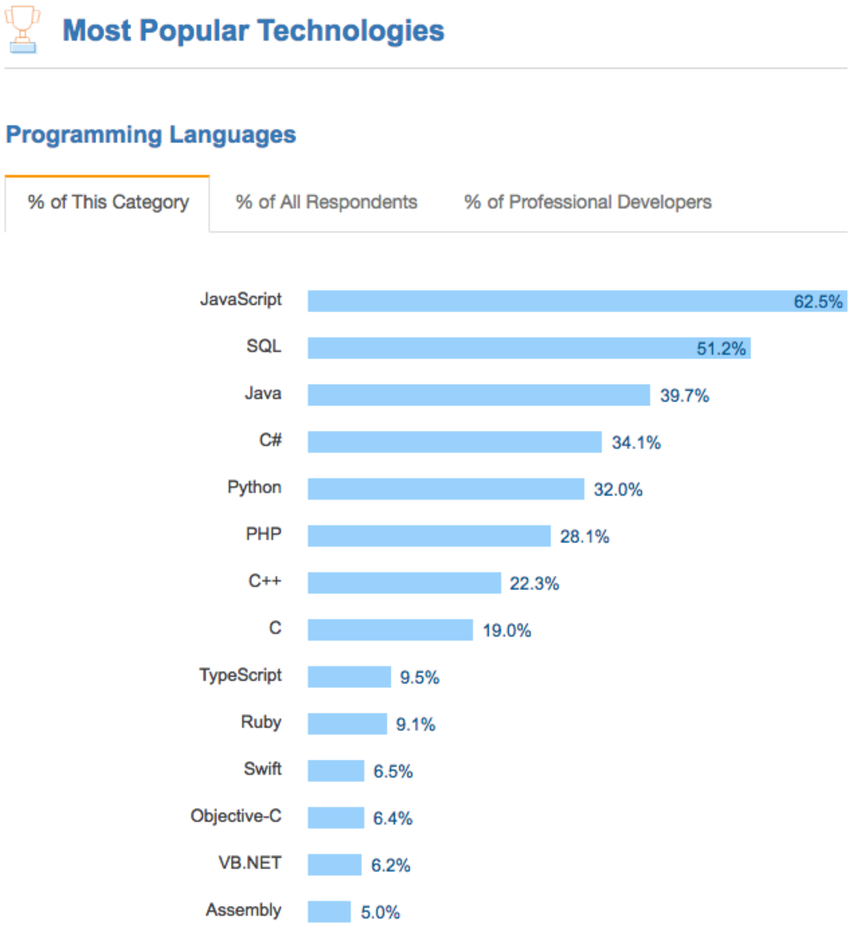
Other web programming languages

- Ruby, via Ruby on Rails
- Python, via Django or web2py
- These days, you can create a dynamic website in almost any language

Other web programming languages

- Some languages transpile to JavaScript
- TypeScript, by Microsoft, introduces types
  - More on TypeScript later
- Kotlin, by Google, runs on the Java virtual machine and compiles to JavaScript
  - Links all of Google's platforms

JavaScript’s popularity



https://insights.stackoverflow.com/survey/2017#technology-programming-languages

How did JavaScript become the most popular language for web development?

History of JavaScript

- *"Developed under the name Mocha, the language was officially called **LiveScript** when it first shipped in beta releases of Netscape Navigator 2.0 in September 1995, but it later was renamed JavaScript"*

- Java's popularity was on the rise
  - Marketing ploy
  - Intended to be the "web" language to Java's "desktop"

https://medium.com/@benastontweet/lesson-1a-the-history-of-javascript-8c1ce3bffb17

History of JavaScript

- Netscape submitted JavaScript to ECMA International for consideration as an industry standard
- Subsequent versions were standardized as “ECMAScript”
- Today, ECMAScript and JavaScript are more or less two different names for the same language

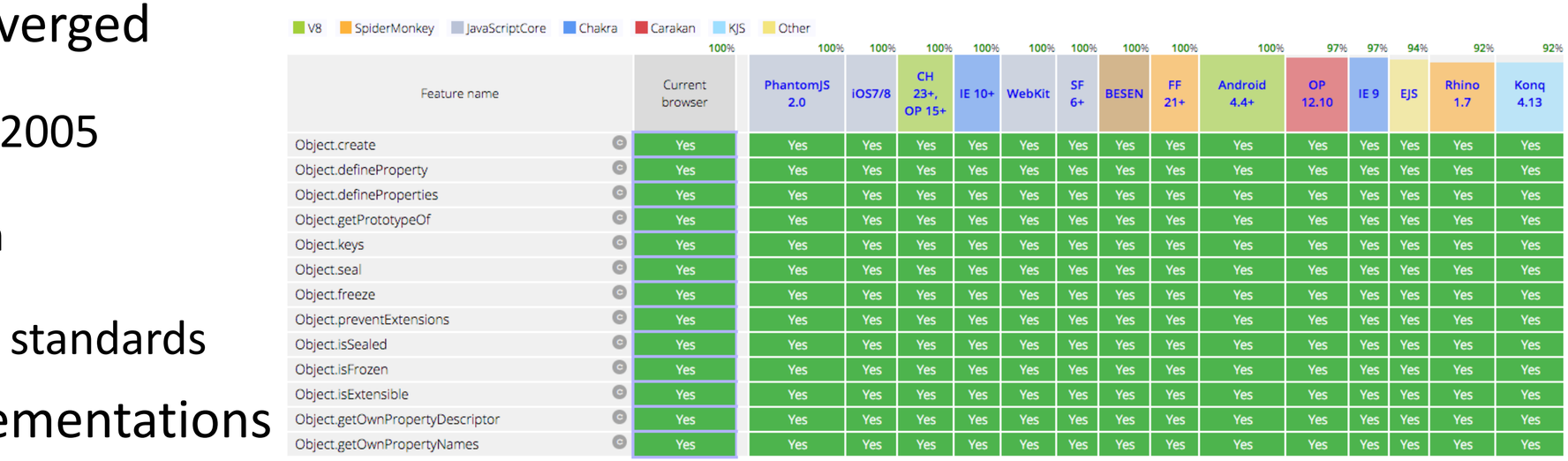
European Computer Manufacturers Association

History of JavaScript

- Alternatives started springing up in the late 1990s and early 2000's
  - Microsoft introduced JScript engine
  - Macromedia Flash's ActionScript
- Both were vaguely JavaScript-like, but standards differed

History of JavaScript

- Standards later converged
  - Firefox came out in 2005
  - Adobe bought Flash
  - JScript followed the standards
- But browser's implementations of the language still vary

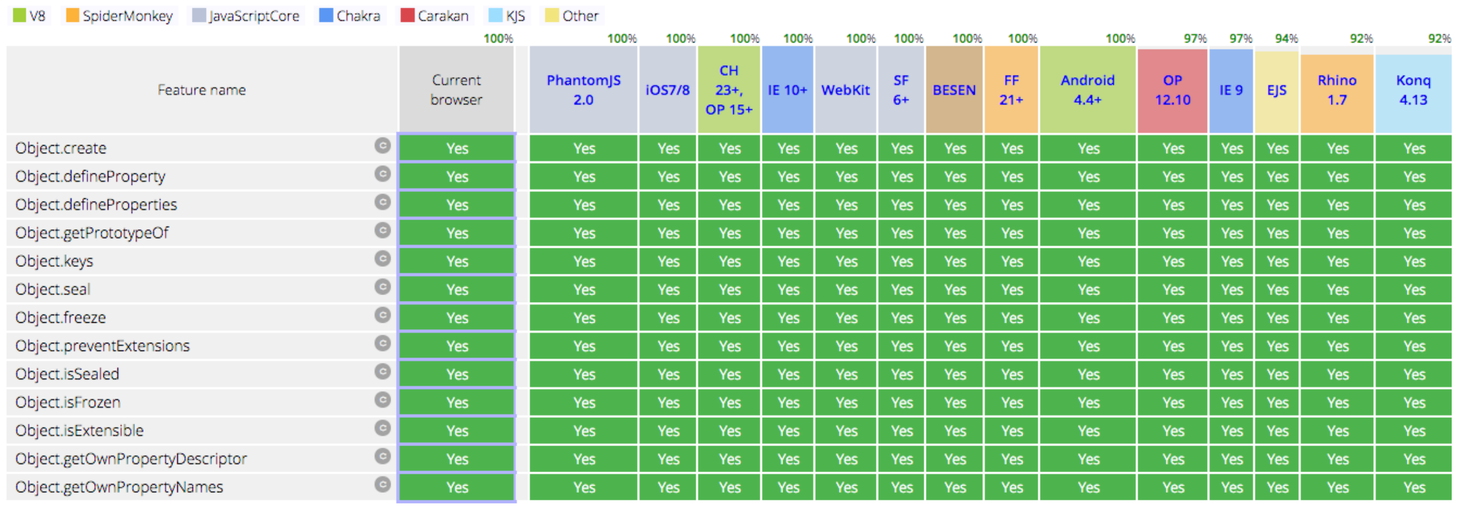


V8 SpiderMonkey JavaScriptCore Chakra Carakan KJS Other

Feature name	Current browser	PhantomJS 2.0	iOS7/8	CH 23+, OP 15+	IE 10+	WebKit	SF 6+	BESEN	FF 21+	Android 4.4+	OP 12.10	IE 9	EJS	Rhino 1.7	Konq 4.13
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%	97%	94%	92%	92%
Object.create	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.defineProperty	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.defineProperties	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.getPrototypeOf	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.keys	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.seal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.freeze	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.preventExtensions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.isSealed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.isFrozen	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.isExtensible	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.getOwnPropertyDescriptor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.getOwnPropertyNames	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

History of JavaScript

- JavaScript Engines
  - SpiderMonkey (Firefox)
  - V8 (Chrome)
  - JavaScriptCore (Safari)
  - Carakan (Opera)
  - Chakra (IE & Edge)



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Object.getOwnPropertyDescriptor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object.getOwnPropertyNames	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Versions of JavaScript

- You may see references to ECMAScript
- ECMAScript is just the standard for JavaScript
  - The last “major” release was ECMAScript 6, or ES6, or ECMAScript 2015, or ES2015
  - The latest is ECMAScript 2020, or ES11, or ES2020 (released in June 2020)

Versions of JavaScript

- Engines/Browsers continually play catch-up,
  so many tools support slightly older versions of the standard

		Compilers/polyfills					Desktop browsers												
	8%	2%	28%	39%	0%	28%	0%	1%	1%	1%	2%	2%	5%	8%	8%	5%	8%	9%	9%
Feature name ▸	Current browser	Traceur	Babel 6 + core-js	Babel 7 + core-js	Closure 2018.09	TypeScript + core-js	IE 11	Edge 16	Edge 17	Edge 18 Preview	FF 60 ESR	FF 61	FF 62	FF 63 Beta	FF 64 Nightly	CH 68, OP 55	CH 69, OP 56	CH 70, OP 57	CH 71, OP 58
Candidate (stage 3)																			
string trimming ▸	4/4	0/4	4/4	4/4	0/4	4/4	0/4	2/4	2/4	2/4	2/4	4/4	4/4	4/4	4/4	4/4	4/4	4/4	4/4
global ▸	0/2	0/2	2/2	2/2	0/2	2/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2
String.prototype.matchAll Ⓒ	No	No	Yes[4]	Yes[4]	No	Yes[5]	No	No	No	No	No	No	No	No	No	Flag[9]	Flag[9]	Flag[9]	Flag[9]
instance class fields ▸	0/3	1/3	1/3	1/3	0/3	1/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0/3
static class fields ▸	0/2	1/2	1/2	1/2	0/2	1/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/2
Function.prototype.toString revision ▸	7/7	0/7	0/7	0/7	0/7	0/7	1/7	4/7	4/7	4/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7	7/7
Array.prototype.{flat, flatMap}[10] ▸	2/2	0/2	1/2	1/2	0/2	1/2	0/2	0/2	0/2	0/2	0/2	0/2	2/2	2/2	2/2	0/2	2/2	2/2	2/2
Symbol.prototype.description Ⓒ	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No	Flag[9]	Yes	Yes
BigInt ▸	8/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	0/8	8/8	8/8	8/8	8/8
Object.fromEntries Ⓒ	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No	No	No	No

Versions of JavaScript

- Polyfills ensure a user's browser has the latest libraries
  - Downloads "fill" versions of added functions, re-written using existing functions
  - Recreates missing features for older browsers
- Sometimes called a "shim" or a "fallback"

JavaScript

- Interpreted language
- Executed by a JavaScript engine
- Engine runs the same code that a programmer writes

Java

- Compiled language (into bytecode)
- Run in a Java Virtual Machine (JVM)
- Bytecode is unreadable by people

JavaScript

- Standardized through ECMAScript, but discrepancies exist
- Debugging dependent on execution environment
- Prototype based
- Used in every browser without a plugin

Java

- “Write once, deploy anywhere”
- Bugs found at compile time
- Class-based
- Requires a plugin to be run in most browsers

JavaScript is just a programming language

Printing in JavaScript

```
console.log("Hello, world!");
```

- Won’t be visible in the browser
- Shows in the JavaScript Console

https://repl.it/@m5b/inf133-javascript-demo#index.html

JavaScript Syntax

- Has functions and objects
  - foo() bar.baz
  - They look like Java, but act differently

JavaScript Variables

- Variables are dynamically typed

```
var x = 'hello'; //value is a string
console.log(typeof x); //string

x = 42; //value is now a Number
console.log(typeof x); //number
```

- Unassigned variables have a value of `undefined`

```
var hoursSlept;
console.log(hoursSlept);
```

JavaScript types

```
console.log('40' + 2); //'402'
console.log('40' - 4); //36
```

Minus isn't defined for strings, so JavaScript knows to convert this

```
var num = 10;
var str = '10';

//comparisons: these will all be booleans (true/false)
console.log(num == str); //true
console.log(num === str); //false
console.log('' == 0); //true
```

=== "strict equality" same as "==" but without type conversion

JavaScript loops and conditionals

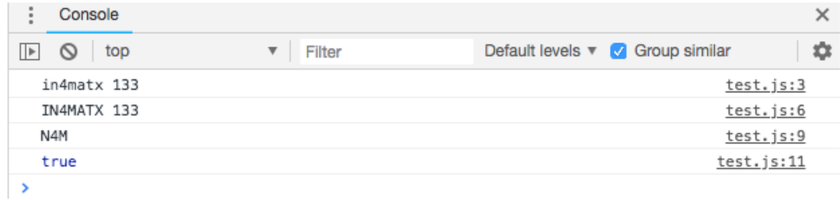
```
var i = 4.4;

if(i > 5) {
  console.log('i is bigger than 5');
} else if(i >= 3) {
  console.log('i is between 3 and 5');
} else {
  console.log('i is less than 3');
}

for(var x = 0; x < 5; x++) {
  console.log(x);
}
```

JavaScript methods

- Called with dot notation




```
var className = 'in4matx 133';
console.log(className);

className = className.toUpperCase();
console.log(className);

var part = className.substring(1, 4);
console.log(part);

console.log(className.indexOf('MATX') >= 0); //whether
the substring appears
```

JavaScript arrays

- Similar to Java, but can be a mix of different types

```
var letters = ['a', 'b', 'c'];
var numbers = [1, 2, 3];
var things = ['raindrops', 2.5, true, [5, 9, 8]]; //arrays can be nested
var empty = [];
var blank5 = new Array(5); //empty array with 5 items

//access using [] notation like Java
console.log( letters[1] ); //=> "b"
console.log( things[3][2] ); //=> 8

//assign using [] notation like Java
letters[0] = 'z';
console.log( letters ); //=> ['z', 'b', 'c']

//assigning out of bounds automatically grows the array
letters[10] = 'g';
console.log( letters);
    //=> [ 'z', 'b', 'c', , , , , , , , , 'g' ]
console.log( letters.length ); //=> 11
```

JavaScript arrays

- Arrays have their own methods

```
//Make a new array
var array = ['i','n','f','x'];

//add item to end of the array
array.push('133');
console.log(array); //=> ['i','n','f','x','133']

//combine elements into a string
var str = array.join('-');
console.log(str); //=> "i-n-f-x-133"

//get index of an element (first occurrence)
var oIndex = array.indexOf('x'); //=> 3

//remove 1 element starting at oIndex
array.splice(oIndex, 1);
console.log(array); //=> [‘i','n','f','133']
```

JavaScript objects

- An unordered set of key and value pairs
  - Like a HashMap in Java or a dictionary in Python
  - Sometimes called *associative arrays*

Quotes around keys are optional

```
ages = {alice:40, bob:35, charles:13}
extensions = {‘mark':1622, 'in4matx':9937}
num_words = {1:'one', 2:'two', 3:'three'}
things = {num:12, dog:'woof', list:[1,2,3]}
empty = {}
empty = new Object(); //empty object
```

JavaScript Object Notation (JSON)

```
{
  "first_name": "Alice",
  "last_name": "Smith",
  "age": 40,
  "pets": ["rover", "fluffy", "mittens"],
  "favorites": {
    "music": "jazz",
    "food": "pizza",
    "numbers": [12, 42]
  }
}
```

- Used in many APIs to send/receive data

Accessing properties

Values (or properties) can be referenced with the array[] syntax

```
ages = {alice:40, bob:35, charles:13}

//access ("look up") values
console.log( ages['alice'] ); //=> 40
console.log( ages['bob'] ); //=> 35
console.log( ages['charles'] ); //=> 13

//keys not in the object have undefined values
console.log( ages['fred']); //=> undefined

//assign values
ages['alice'] = 41;
console.log( ages['alice'] ); //=> 41

ages['fred'] = 19; //adds the key and assigns
                   //a value to it
```

Accessing properties

Values can also be referenced with dot notation

```
var person = {
  firstName: 'Alice',
  lastName: 'Smith',
  favorites: {
    food: 'pizza',
    numbers: [12, 42]
  }
};

var name = person.firstName; //get value of 'firstName' key
person.lastName = 'Jones'; //set value of 'lastName' key
console.log(person.firstName+' '+person.lastName); //"Alice Jones"

var topic = 'food'
var favFood = person.favorites.food; //object in the object
              //object          //value

var firstNumber = person.favorites.numbers[0]; //12
person.favorites.numbers.push(7); //push 7 onto the Array
```

Functions

Functions in JavaScript are like static methods in Java

```
//Java
public static String sayHello(String name){
    return "Hello, "+name;
}
public static void main(String[] args){
    String msg = sayHello("IN4MATX 133");
}
```

Parameters have no type

```
//JavaScript
function sayHello(name){
    return "Hello, "+name;
}
```

Parameters are comma-separated

No access modifier or return type

```
var msg = sayHello("IN4MATX 133");
```

Functions

In Javascript, all parameters are optional

```
function sayHello(name)
{
    return "Hello, "+name;
}

//expected; parameter is assigned a value
sayHello("In4MATX 133"); //"Hello, IN4MATX 133"

//parameter not assigned value (left undefined)
sayHello(); //"Hello, undefined"

//extra parameters (values) are not assigned
//to variables, so are ignored
sayHello("IN4MATX","133"); //"Hello, IN4MATX"
```

Now for the confusing part…

Functions are objects

```
//assign array to variable
var myArray = ['a','b','c'];


var other = myArray;

//access value in other
console.log( other[1] ); //print 'b'
```

```
//assign function to variable
function sayHello(name) {
    console.log("Hello, "+name);
}

var other = sayHello;

//prints "Hello, everyone"
other('everyone');
```

Functions are objects

```
//assign array to variable
var myArray = ['a','b','c'];


var other = myArray;

//access value in other
console.log( other[1] ); //print 'b'
```

```
//assign function to variable
var sayHello = function(name) {
   console.log("Hello, "+name);
}

//second variable, same object
var greet = sayHello;

//execute object named `greet`
greet('everyone');
    //prints "Hello, everyone"
```

Functions are objects

```
var obj = {};
var myArray = ['a','b','c'];


//assign array to object
obj.array = myArray;

//access with dot notation
obj.array[0]; //gets 'a'


//assign literal (anonymous value)
obj.otherArray = [1,2,3]
```

```
var obj = {}
function sayHello(name) {
    console.log("Hello, "+name);
}

//assign function to object
var obj.sayHi = sayHello;

//access with dot notation
obj.sayHi('all'); //prints "Hello all"


//assign literal (anonymous value)
obj.otherFunc = function() {
     console.log("Hello world!");
}
```

How “non-static” methods are made

Anonymous variables

```
var array = [1,2,3]; //named variable (not anonymous)
console.log(array); //pass in named var

console.log( [4,5,6] ); //pass in anonymous value
```

Anonymous variables

```
//named function
function sayHello(person){
    console.log("Hello, "+person);
}

//anonymous function (no name!)
function(person) {
    console.log("Hello, "+person);
}

//anonymous function (value) assigned to variable
var sayHello = function(person) {
    console.log("Hello, "+person);
}
```

Anonymous variables

```
//anonymous functions often follow
an “arrow” (abbreviated) syntax
var sayHello = (person) => {
    console.log("Hello, "+person);
}

sayHello('IN4MATX 133');
```

`this` keyword

- `this` usually refers to the object that the method was called on
- `this` is only preserved with abbreviated (arrow) syntax

```
var alice = {
   first: 'Alice',
   last: 'Jones',
   sayHello:()=> {
      console.log("Hello, I'm " + this.first);
   }
};

alice.sayHello(); //=> "Hello, I'm Alice"
```

Refers to containing object (alice)

Passing functions

Since functions are objects, they can be passed like variables

```
//anonymous function syntax
var doAtOnce = function(funcA, funcB) {
    funcA();
    console.log(' and ');
    funcB();
    console.log(' at the same time! ');
}

var patHead = function(name) {
    console.log("pat your head");
}

var rubBelly = function(name) {
    console.log("rub your belly");
}
```

No parens … (),
just passing variable

```
doAtOnce(patHead, rubBelly);
```

Callback functions

- A function that is passed to *another* function for it to “call back to” and execute

```
function doLater(callback) {
  console.log("I'm waiting a bit...");
  console.log("Okay, time to work!");
  callback();
}

function doHomework() {
  ...
};

doLater(doHomework);
```

Takes in a callback

Pass in the callback function

Callback function example: `forEach`

- To iterate through each item in a loop, use the `forEach` function and pass it a function to call on each array item

```
//Iterate through an array
var array = ['a','b','c'];
var printItem = function(item) {
    console.log(item);
}

array.forEach(printItem);

//more common to use anonymous function
array.forEach(function(item) {
    console.log(item);
});
```

Callback

Callback function example: `map`

- `map` applies the function to each element in an array and returns a *new* array of elements returned by the function

```
var array = [1,2,3];
var squared = function(n) {
    return n*n;
};

array.map(squared); //returns [1,4,9]

//more common to do this inline:
array.map(function(n) {
    return n*n;
});
```

Callback function example: `filter`

- `filter` applies the function to each element in an array and returns a *new* array of only the elements for which the function returns true.

```
var array = [3,1,4,2,5];

var isACrowd = array.filter(function(n) {
    return n >= 3;
}); //returns [3,4,5]
```

Callback function example: `reduce`

- `reduce` applies the function to each element in an array to update an "accumulator" value. The callback function should return the "updated" value for the accumulator.

```
var array = [1,2,3,4];

var sum = array.reduce(function(total, current) {
    var newTotal = total + current;
    return newTotal;
}, 0); //returns 1+2+3+4=10
```

Today’s goals

By the end of today, you should be able to…

- Explain the different roles HTML, CSS, and JavaScript play
- Describe how JavaScript standards evolved
- Follow JavaScript syntax for traditional programming concepts like typing, variable assignment, loops, and conditionals
- Differentiate the roles of arrays and associative arrays
- Implement functional programming concepts in JavaScript like forEach, map, and filter