The JavaScript Language (Part 1)

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Objectives

- We will cover:
  - A subset of JavaScript…
  - That is appropriate for COS 333…
  - Through example programs

Agenda

- **Overview**
- Setup
- Simple programs
- Functions
- Standard library
- Data types and operators
- Terminal I/O
- Exceptions
- Statements

Overview

Brendan Eich

Overview: Motivation

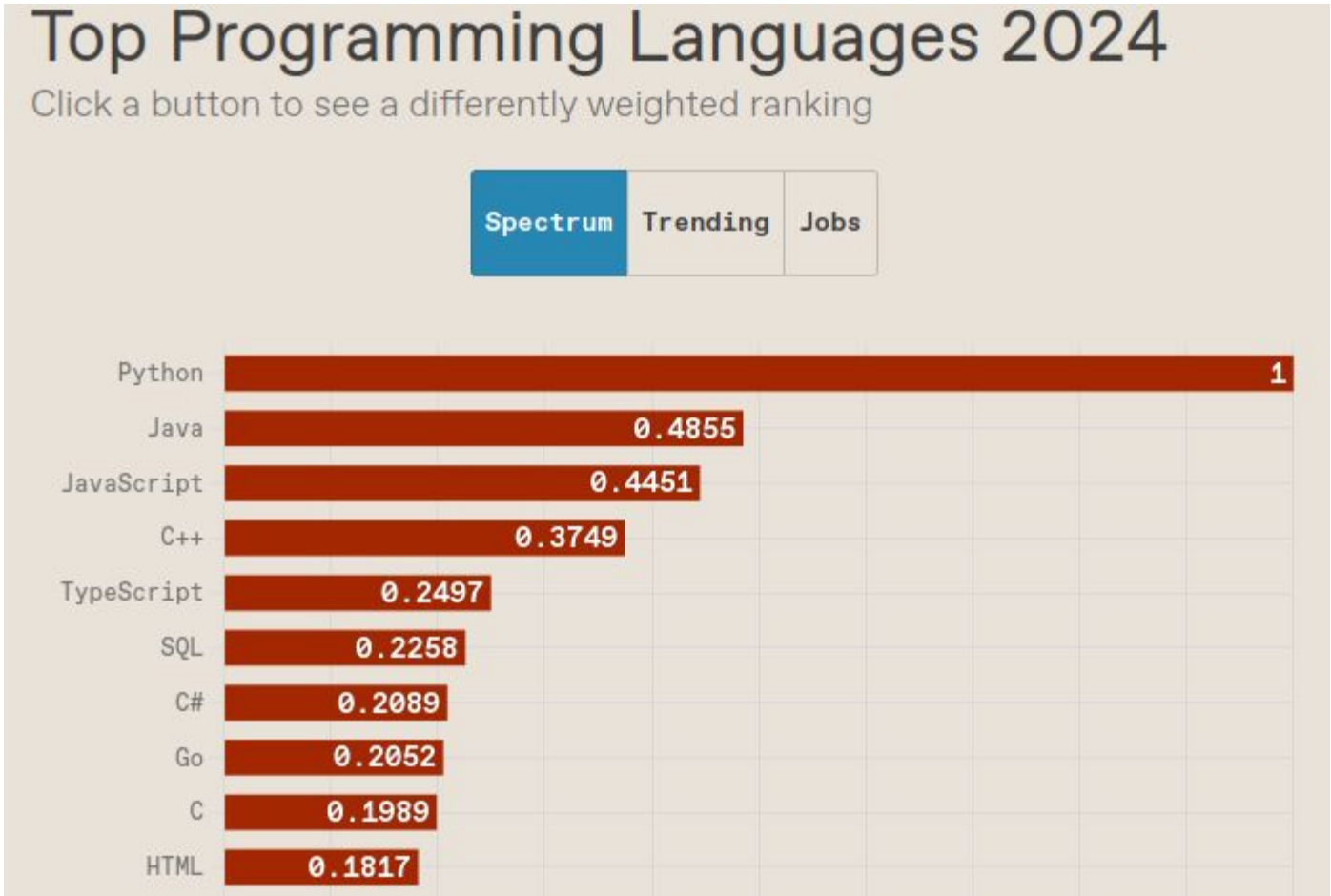
- **Question**:
  - Why study JavaScript?
- **Answer**: …

Overview: Motivation

Rank	Language	Ratings
1	Python	21.9%
2	C++	11.6%
3	Java	10.5%
4	C	8.4%
5	C#	5.6%
6	**JavaScript**	3.5%
7	Visual Basic	2.4%
8	Go	2.0%
9	FORTRAN	1.8%
10	Delphi/Object Pascal	1.7%
11	SQL	1.6

https://www.tiobe.com/tiobe-index/ on 10/20/24

Overview: Motivation



https://spectrum.ieee.org/the-top-programming-languages-2024

Overview: Motivation

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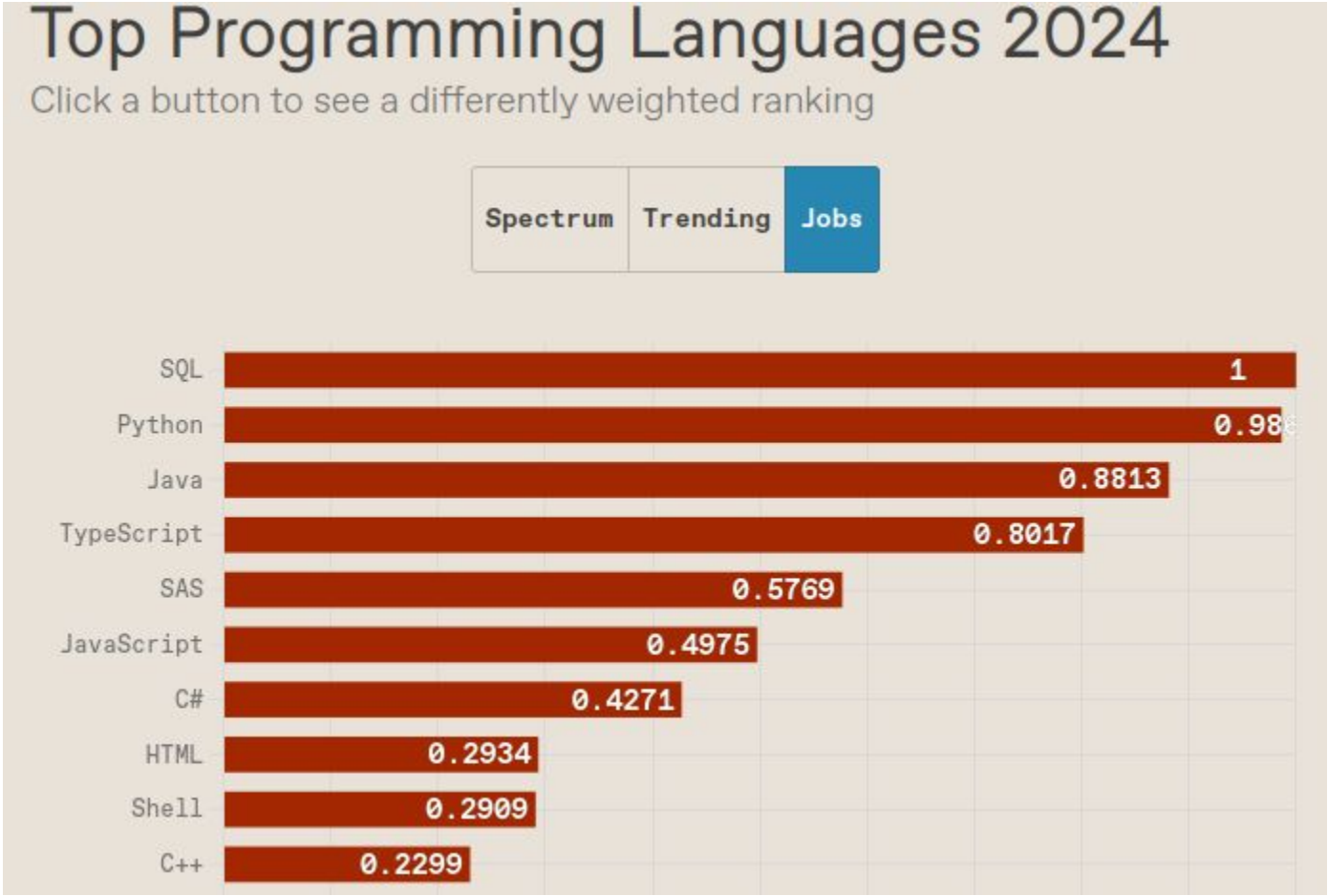
Overview: Motivation



https://spectrum.ieee.org/the-top-programming-languages-2024

Overview: Motivation

Website	Front End	Back End
Google	**JavaScript, TypeScript**	C, C++, Go, Java, Python, Node
Facebook	**JavaScript, TypeScript**	Hack, Python, C++, Java, Erlang, D, Haskell
YouTube	**JavaScript, TypeScript**	Python, C, C++, Java,Go
Yahoo	**JavaScript**	PHP
Etsy	**JavaScript**	PHP
Amazon	**JavaScript**	Java, C++, Perl
Wikipedia	**JavaScript**	PHP
Fandom	**JavaScript**	PHP
X	**JavaScript**	C++, Java, Scala, Ruby
Bing	**JavaScript**	C++, C#
eBay	**JavaScript**	Java, JavaScript, Scala

https://en.wikipedia.org/wiki/Programming_languages_used_in_most_popular_websites (10/20/24)

Overview: ECMAScript

- JavaScript is an implementation of…
- ***ECMAScript***
  - By **E**uropean **C**omputer **M**anufacturer's **A**ssociation
  - Latest specification:
    - https://tc39.es/ecma262/

Overview: ECMAScript

Year	Name	Description
1997	***ECMAScript1*** ***ES1***	First edition
1998	***ECMAScript2*** ***ES2***	Editorial changes only
1999	***ECMAScript3*** ***ES3***	Added regular expressions **Added try/catch**
	ECMAScript4 ***ES4***	Never released

https://www.w3schools.com/js/js_versions.asp

Overview: ECMAScript

Year	Name	Description
2009	*ECMAScript5* *ES5*	**Added "strict mode"** Added JSON support Added String.trim() Added Array.isArray() Added Array Iteration Methods
2011	*ECMAScript5.1* *ES5.1*	Editorial changes
2015	*ECMAScript6* *ECMAScript2015* *ES6*	**Added let and const** **Added default parameter values** Added Array.find() Added Array.findIndex() **Added classes** **Added promises**

https://www.w3schools.com/js/js_versions.asp

Overview: ECMAScript

Year	Name	Description
2016	*ECMAScript7* *ECMAScript2016* *ES7*	Added exponential operator (**) Added Array.prototype.includes
2017	*ECMAScript8* *ECMAScript2017* *ES8*	Added string padding Added new Object properties **Added Async functions** Added Shared Memory
2018	*ECMAScript9* *ECMAScript2018* *ES9*	Added rest / spread properties Added Asynchronous iteration Added Promise.finally() Additions to RegExp

https://www.w3schools.com/js/js_versions.asp

Overview: ECMAScript

Year	Name	Description
2019	***ECMAScript10*** ***ECMAScript 2019*** ***ES10***	Added Array.prototype.flat Added Array.prototype.flatMap Changed Array.sort and Object.fromEntries
2020	***ECMAScript11*** ***ECMAScript2020*** ***ES11***	Added BigInt Added null coalescing syntax
2021	***ECMAScript12*** ***ECMAScript2021*** ***ES12***	Added replaceAll for strings Added Promise.any Added AggregateError

https://www.w3schools.com/js/js_versions.asp

Overview: ECMAScript

Year	Name	Description
2022	*ECMAScript13* *ECMAScript2022* *ES13*	Added top-level await Added private class fields
2023	*ECMAScript14* *ECMAScript2023* *ES14*	Added functions to Array.prototype Added #! support
2024	*ECMAScript15* *ECMAScript2024* *ES15*	

https://www.w3schools.com/js/js_versions.asp

Overview: Transpiling

- **Problem**:
  - You create JavaScript code that uses some ES6 syntax
  - You want your code to be runnable on all browsers
  - Some old-but-still-widely-used browsers can interpret only ES5 syntax

Overview: Transpiling

- **Solution**: ***Transpile***
  - You transpile your code from ES6 to ES5
  - You provide your code to browsers as ES5
  - Example transpiler: ***Babel***

Overview: Polyfilling

- **Problem**:
  - You create some JavaScript code that uses ES5 syntax, but also uses some new modules – modules that are available only on new (post-ES5) browsers
  - You want your code to be runnable on ES5 browsers

Overview: Polyfilling

- **Solution**: ***Polyfill***
  - You polyfill those new modules
  - You compose your own versions of those new modules and include them in your code
  - Or better…
  - You include in your code an already vetted set of polyfills

Overview: Learning JavaScript

- **Commentary**
  - To learn ES*n*, you must also learn ES*n-1*, ES*n-2*, …, ES1
  - JavaScript is a particularly difficult language to master

Overview: Running JavaScript

- Options for running JavaScript:
  - In browser (soon)
  - Via ***Node.js*** (now)

Overview: Node.js

Ryan
Dahl

Agenda

- Overview
- **Setup**
- Simple programs
- Functions
- Standard library
- Data types and operators
- Terminal I/O
- Exceptions
- Statements

Setup

- **Step 1**: Install Node.js and npm
  - Linux
    - Use your package manager to install the node and npm packages
  - Mac
    - Use Homebrew to install Node.js by issuing this command:
      - `brew install node`
  - MS Windows
    - Browse to https://nodejs.org/en/download
    - Download an appropriate .msi file
    - In Windows Explorer, double click on the .msi file
    - Use the installation defaults

Setup

- **Step 2**: Install Node.js modules
  - At shell prompt
    - cd to the directory that contains JavaScript code
    - Install the `readline-sync` module
      - `npm install readline-sync`

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Simple Programs

- See **hello1.js**

```
$ node hello1.js
hello, world
$
```

Simple Programs

- See **hello2.js**

```
$ node hello2.js
hello, world
$
```

hello1.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // hello1.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: 'use strict';
 7:
 8: process.stdout.write('hello, world\n');
 9:
10: // Alternative:
11: // console.log('hello, world');  // Always appends a newline.
12:
```

hello2.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // hello2.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: 'use strict';
 7:
 8: function main() {
 9:    process.stdout.write('hello, world\n');
10: }
11:
12: if (require.main === module)
13:    main();
```

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Functions

- See **square.js**

```
$ node square.js
25
25
25
25
25
$
```

square.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // square.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: 'use strict';
 7:
 8: // Function definition statement
 9: function square1(i) {
10:    return i * i;
11: }
12:
13: // Function definition expression
14: let square2 = function(i) {
15:    return i * i;
16: };
17:
18: // Arrow function definition expression
19: let square3 = (i) => {return i * i;};
20: let square4 = (i) => i * i;
21: let square5 = i => i * i;
22:
23: function main() {
24:    let sqr1 = square1(5);
25:    let sqr2 = square2(5);
26:    let sqr3 = square3(5);
27:    let sqr4 = square4(5);
28:    let sqr5 = square5(5);
29:
30:    process.stdout.write(String(sqr1) + '\n');
31:    process.stdout.write(String(sqr2) + '\n');
32:    process.stdout.write(String(sqr3) + '\n');
33:    process.stdout.write(String(sqr4) + '\n');
34:    process.stdout.write(String(sqr5) + '\n');
35: }
36:
37: if (require.main === module)
38:    main();
```

squareroot.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // squareroot.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: 'use strict';
 7:
 8: function main() {
 9:    let sqrtOfTwo = Math.sqrt(2.0);
10:    process.stdout.write(String(sqrtOfTwo) + '\n');
11: }
12:
13: if (require.main === module)
14:    main();
```

Aside: “Never Fail” Design

- “Never fail”
  - Pervasive JavaScript design philosophy

```
function square1(i) {
   return i * i;
}
…
n = square1(5);     // What happens?
n = square1(5, 6); // What happens?
n = square1();      // What happens?
```

Aside: The Arguments Array

- The `arguments` array

```
function sumall() {
   let sum = 0;
   for (let i = 0; i < arguments.length; i++)
      sum += arguments[i];
   return sum;
}
…
n = sumall();           // 0
n = sumall(5);          // 5
n = sumall(5, 6, 7);    // 18
```

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Standard Library

- See **squareroot.js**

```
$ node squareroot.js
1.4142135623730951
$
```

Full list of built-in objects in ES15:

https://tc39.es/ecma262/

Full list of built-in objects in Mozilla:
https://developer.Mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects

square.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // square.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: 'use strict';
 7:
 8: // Function definition statement
 9: function square1(i) {
10:    return i * i;
11: }
12:
13: // Function definition expression
14: let square2 = function(i) {
15:    return i * i;
16: };
17:
18: // Arrow function definition expression
19: let square3 = (i) => {return i * i;};
20: let square4 = (i) => i * i;
21: let square5 = i => i * i;
22:
23: function main() {
24:    let sqr1 = square1(5);
25:    let sqr2 = square2(5);
26:    let sqr3 = square3(5);
27:    let sqr4 = square4(5);
28:    let sqr5 = square5(5);
29:
30:    process.stdout.write(String(sqr1) + '\n');
31:    process.stdout.write(String(sqr2) + '\n');
32:    process.stdout.write(String(sqr3) + '\n');
33:    process.stdout.write(String(sqr4) + '\n');
34:    process.stdout.write(String(sqr5) + '\n');
35: }
36:
37: if (require.main === module)
38:    main();
```

squareroot.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // squareroot.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: 'use strict';
 7:
 8: function main() {
 9:    let sqrtOfTwo = Math.sqrt(2.0);
10:    process.stdout.write(String(sqrtOfTwo) + '\n');
11: }
12:
13: if (require.main === module)
14:    main();
```

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- **Data types and operators**
- **Terminal I/O**
- Exceptions
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Data Types and Operators

- See **circle1.js**

```
$ node circle1.js
Enter the circle's radius:
5
A circle with radius 5 has diameter 10
and circumference 31.41592653589793.
$ node circle1.js
Enter the circle's radius:
1
A circle with radius 1 has diameter 2
and circumference 6.283185307179586.
$
```

circle1.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // circle1.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: // Before running this program you must install the readline-sync
 7: // module.  You can do that by issuing this command:
 8: // npm install readline-sync
 9:
10: 'use strict';
11:
12: const readlineSync = require('readline-sync');
13:
14: function main() {
15:    let line = readlineSync.question("Enter the circle's radius:\n");
16:    let radius = Number(line);
17:
18:    let diam = 2 * radius;
19:    let circum = Math.PI * diam;
20:
21:    process.stdout.write('A circle with radius ' + String(radius) +
22:       ' has diameter ' + String(diam) + '\n');
23:    process.stdout.write('and circumference ' + String(circum) + '.\n');
24: }
25:
26: if (require.main === module)
27:    main();
```

circle2.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // circle2.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: // Before running this program you must install the readline-sync
 7: // module.  You can do that by issuing this command:
 8: // npm install readline-sync
 9:
10: 'use strict';
11:
12: const readlineSync = require('readline-sync');
13:
14: function main() {
15:    try {
16:       let line = readlineSync.question(
17:          "Enter the circle's radius:\n");
18:       if (line === '')
19:          throw new Error('Missing number');
20:
21:       if (isNaN(line))
22:          throw new Error('Not a number');
23:       let radius = Number(line);
24:
25:       let diam = 2 * radius;
26:       let circum = Math.PI * diam;
27:
28:       process.stdout.write('A circle with radius ' + String(radius) +
29:          ' has diameter ' + String(diam) + '\n');
30:       process.stdout.write('and circumference ' + String(circum) +
31:          '.\n');
32:    }
33:    catch (e) {
34:       process.stderr.write(String(e) + '\n');
35:    }
36: }
37:
38: if (require.main === module)
39:    main();
```

Data Types and Operators

Data Type	Size	Example Literals
Boolean	1 byte	`false, true`
String	(varies)	`"hi", 'hi'`
Number	8 bytes	`123, -123, 0.0, 1.23, 1.23e4`

All numbers are stored as IEEE 754 floating point

Data Types and Operators

- Type conversion functions
  - `Number(x)`
  - `Boolean(x)`
  - `String(x)`

Data Types and Operators

- Strong suggestion
  - **Use the type conversion functions** to avoid mixed-type expressions!

Recommended viewing:
https://www.destroyallsoftware.com/talks/wat

Data Types and Operators

Operators	(Priority) Meaning
`(…)`	(1) Grouping
`x.y`	**(2) Member access**
`x[y]`	**(2) Computed member access**
`new …`	**(2) New**
`f(…)`	(2) Function call
`x?.y`	(2) Optional chaining
`new`	(3) New without operator list
`x++`	(4) Postfix increment
`x--`	(4) Postfix decrement

Data Types and Operators

Operators	(Priority) Meaning
`!x`	(5) Logical NOT
`~x`	(5) Bitwise NOT
`+x`	(5) Unary plus
`-x`	(5) Unary negation
`++x`	(5) Prefix increment
`--x`	(5) Prefix decrement
`typeof x`	(5) typeof
`void x`	(5) void
`delete x`	(5) delete
`await x`	(5) await
`x**y`	(6) Exponentiation

Data Types and Operators

Operators	(Priority) Meaning
x*y	(7) Multiplication
x/y	(7) Division
x%y	(7) Remainder
x+y	(8) Addition
x-y	(8) Subtraction
x<<y	(9) Bitwise left shift
x>>y	(9) Bitwise right shift
x>>>y	(9) Bitwise unsigned right shift
x<y	(10) Less than
x<=y	(10) Less than or equal to
x>y	(10) Greater than
x>=y	(10) Greater than or equal to
x in y	(10) In
x instanceof y	(10) Instance of

Data Types and Operators

Operators	(Priority) Meaning
`x==y`	**(11) Equality**
`x!=y`	(11) Inequality
`x===y`	**(11) Strict equality**
`x!==y`	(11) Strict inequality
`x&y`	(12) Bitwise AND
`x^y`	(13) Bitwise exclusive OR
`x|y`	(14) Bitwise OR
`x&&y`	(15) Logical AND
`x||y`	(16) Logical OR
`x??y`	(17) Nullish coalescing operator
`x?y:z`	(18) Conditional

Data Types and Operators

Operators	(Priority) Meaning
x=y, x+=y, x-=y, x**=y, **x*=y, x/=y, x%=y,** x<<=y, x>>=y, x>>>=y, x&=y, x^=y, x|=y, x&&=y, x||=y, x??=y	(18) Assignment
yield x	(19) Yield
yield* x	(20) Yield
x,y	(21) Sequence

Data Types and Operators

Expression	Value
`123 == '123'`	`true`
`123 == '+123'`	`true`
`123 === '123'`	`false`
`123 === '+123'`	`false`

Equality operator (==) does type conversion

Strict equality operator (===) suppresses type conversion

Recommendation: Always use === instead of ==

Recommendation: Never mix types!!!

Terminal I/O

Reading from stdin:

```
const readlineSync = require('readline-sync');
…
str = readlineSync.question(str);
str = readlineSync.question();
```

Terminal I/O

Writing to stdout:

```
process.stdout.write(strExpr);
console.log(expr);
```

Writing to stderr:

```
process.stderr.write(strExpr);
console.error(expr);
```

Agenda

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Exceptions

- Recall circle1.js

```
$ node circle1.js
Enter the circle's radius:
5
A circle with radius 5 has diameter 10
and circumference 31.41592653589793.
$ node circle1.js
Enter the circle's radius:
xyz
A circle with radius NaN has diameter NaN
and circumference NaN.
$ node circle1.js
Enter the circle's radius:
A circle with radius 0 has diameter 0
and circumference 0.
$
```

Exceptions

- See **circle2.js**

```
$ node circle2.js
Enter the circle's radius:
5
A circle with radius 5 has diameter 10
and circumference 31.41592653589793.
$ node circle2.js
Enter the circle's radius:
xyz
Error: Not a number
$ node circle2.js
Enter the circle's radius:
Error: Missing number
$
```

circle1.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // circle1.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: // Before running this program you must install the readline-sync
 7: // module.  You can do that by issuing this command:
 8: // npm install readline-sync
 9:
10: 'use strict';
11:
12: const readlineSync = require('readline-sync');
13:
14: function main() {
15:    let line = readlineSync.question("Enter the circle's radius:\n");
16:    let radius = Number(line);
17:
18:    let diam = 2 * radius;
19:    let circum = Math.PI * diam;
20:
21:    process.stdout.write('A circle with radius ' + String(radius) +
22:       ' has diameter ' + String(diam) + '\n');
23:    process.stdout.write('and circumference ' + String(circum) + '.\n');
24: }
25:
26: if (require.main === module)
27:    main();
```

circle2.js (Page 1 of 1)

```
 1: //---------------------------------------------------------------------------
 2: // circle2.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------------
 5:
 6: // Before running this program you must install the readline-sync
 7: // module.  You can do that by issuing this command:
 8: // npm install readline-sync
 9:
10: 'use strict';
11:
12: const readlineSync = require('readline-sync');
13:
14: function main() {
15:    try {
16:       let line = readlineSync.question(
17:          "Enter the circle's radius:\n");
18:       if (line === '')
19:          throw new Error('Missing number');
20:
21:       if (isNaN(line))
22:          throw new Error('Not a number');
23:       let radius = Number(line);
24:
25:       let diam = 2 * radius;
26:       let circum = Math.PI * diam;
27:
28:       process.stdout.write('A circle with radius ' + String(radius) +
29:          ' has diameter ' + String(diam) + '\n');
30:       process.stdout.write('and circumference ' + String(circum) +
31:          '.\n');
32:    }
33:    catch (e) {
34:       process.stderr.write(String(e) + '\n');
35:    }
36: }
37:
38: if (require.main === module)
39:    main();
```

Exceptions

JavaScript standard exceptions:

```
Error
    EvalError
    RangeError
    ReferenceError
    SyntaxError
    TypeError
    URIError
    AggregateError
    InternalError
```

https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects

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- **Statements**

Statements

- See **euclidclient1.js**

```
$ node euclidclient1.js
Enter the first integer:
8
Enter the second integer:
12
gcd: 4
lcm: 24
$
```

euclidclient1.js (Page 1 of 2)

```
 1: //---------------------------------------------------------------------
 2: // euclidclient1.js
 3: // Author: Bob Dondero
 4: //---------------------------------------------------------------------
 5:
 6: 'use strict';
 7:
 8: const readlineSync = require('readline-sync');
 9:
10: //---------------------------------------------------------------------
11:
12: function gcd(i, j) {
13:    if ((i === 0) && (j === 0))
14:       throw new Error('Computation is undefined');
15:
16:    i = Math.abs(i);
17:    j = Math.abs(j);
18:    while (j !== 0) {
19:       let temp = i % j;
20:       i = j;
21:       j = temp;
22:    }
23:    return i;
24: }
25:
26: //---------------------------------------------------------------------
27:
28: function lcm(i, j) {
29:    if ((i === 0) || (j === 0))
30:       throw new Error('Computation is undefined');
31:
32:    i = Math.abs(i);
33:    j = Math.abs(j);
34:    return (i / gcd(i, j)) * j;
35: }
36:
37: //---------------------------------------------------------------------
38:
39: function readInt(prompt) {
40:    let line = readlineSync.question(prompt);
41:    if (line === '')
42:       throw new Error('Missing integer');
43:    if (isNaN(line))
44:       throw new Error('Not a number');
45:    let n = Number(line);
46:    if (! Number.isInteger(n))
47:       throw new Error('Not an integer');
48:    return n;
49: }
50:
51: //---------------------------------------------------------------------
52:
53: function main() {
54:    try {
55:       let i = readInt('Enter the first integer:\n');
56:       let j = readInt('Enter the second integer:\n');
57:
58:       let myGcd = gcd(i, j);
59:       process.stdout.write('gcd: ' + String(myGcd) + '\n');
60:
61:       let myLcm = lcm(i, j);
62:       process.stdout.write('lcm: ' + String(myLcm) + '\n');
63:    }
64:    catch (e) {
65:       process.stderr.write(e + '\n');
```

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```
66:    }
67: }
68:
69: if (require.main === module)
70:    main();
71:
```

Statements

Compound statement

```
{
    statement1;
    statement2;
    …
}
```

Statements

Variable definition statements

```
let name = expr;
const name = expr;

// Pre-ES6
var name = expr; // name is "hoisted"
```

Aside: Hoisting

```
'use strict';
…
function f() {
    … // Not OK to use n here.
    let n = 5;
    … // OK to use n here.
}
```

```
'use strict';
…
function f() {
    … // OK to use n here.
    … // But its value is undefined.
    var n = 5;
    … // OK to use n here.
}
```

Statements

Function call statement

```
f(expr, expr, ...);
```

`return` statement

```
return;
return expr;
```

Statements

`if` statement

```
if (expr)
   statement;
else
   statement;
```

`false, 0, "", '', null, undefined, NaN` mean logical FALSE

Any other value indicates logical TRUE

Statements

`while` statement

```
while (expr)
   statement;
```

`false, 0, "", '', null, undefined, NaN` mean logical FALSE

Any other value indicates logical TRUE

Statements

`do`…`while` statement

```
do
   statement;
while (expr);
```

`false, 0, "", '', null, undefined, NaN` mean logical FALSE

Any other value indicates logical TRUE

Statements

`for` statements (by example)

```
for (let i = 0; i < 10; i++)
   statement;
for (let i = 0; i < someArray.length; i++)
   …someArray[i]…
for (let element of someArray)
   …element…
for (let property in someObject)
   …property…
```

Statements

`break` statement

```
break;
```

`continue` statement

```
continue;
```

Statements

`try` statement

```
try
    statement;
catch (exception)
    statement;
```

`throw` statement

```
throw object;
```

Summary

- We have covered:
  - Overview
  - Setup
  - Simple programs
  - Functions
  - Standard library
  - Data types and operators
  - Terminal I/O
  - Exceptions
  - Statements