CSC309: Introduction to Web Programming

Lecture 4

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JavaScript Overview

- History
- Language
- Advanced Features
- Platforms
- Standards
- Style

Sources of Misunderstanding

- The Name
- Mispositioning
- Design Errors
- Bad Implementations
- The Browser
- Bad Books
- Substandard Standard
- JavaScript is a Functional Language

History

- 1992
  - Oak, Gosling at Sun & FirstPerson
- 1995
  - Java
  - LiveScript at Netscape
- 1996
  - JScript at Microsoft
- 1998
  - ECMAScript

Not a Web Toy

- It is a real language
- Small, but sophisticated
- It is not a subset of Java

Key Ideas

- Load and go delivery
- Loose typing
- Objects as general containers
- Prototypal inheritance
- Lambda
- Linkage though global variables

Values

- Numbers
- Strings
- Booleans
- Objects
- **`null`**
- **`undefined`**

Numbers

- Only one number type

  No integers

- 64-bit floating point
- IEEE-754 (aka "**Double**")
- Does not map well to common understanding of arithmetic:
- **0.1 + 0.2 = 0.30000000000000004**

NaN

- Special number: Not a Number
- Result of undefined or erroneous operations
- Toxic: any arithmetic operation with **`NaN`** as an input will have **`NaN`** as a result
- **`NaN`** is not equal to anything, including **`NaN`**

Number function

```
Number(value)
```

- Converts the value into a number.
- It produces **NaN** if it has a problem.
- Similar to **+** prefix operator.

parseInt function

```
parseInt(value, 10)
```

- Converts the value into a number.
- It stops at the first non-digit character.
- The radix (**10**) should be required.

```
parseInt("08") === 0
parseInt("08", 10) === 8
```

Math

- Math object is modeled on Java's Math class.
- It contains

abs	absolute value
floor	integer
log	logarithm
max	maximum
pow	raise to a power
random	random number
round	nearest integer
sin	sine
sqrt	square root

Strings

- Sequence of 0 or more 16-bit characters
  - UCS-2, not quite UTF-16
- No separate character type
  - Characters are represented as strings with a length of 1
- Strings are immutable
- Similar strings are equal (==)
- String literals can use single or double quotes

String `length`

- `string.length`

- The **`length`** property determines the number of 16-bit characters in a string.

String function

```
String(value)
```

- Converts value to a string

String Methods

- `charAt`
- `concat`
- `indexOf`
- `lastIndexOf`
- `match`
- `replace`
- `search`
- `slice`
- `split`
- `substring`
- `toLowerCase`
- `toUpperCase`

Booleans

- `true`
- `false`

Boolean function

```
Boolean(value)
```

- returns **`true`** if value is truthy
- returns **`false`** if value is falsy
- Similar to **`!!`** prefix operator

null

- A value that isn't anything

`undefined`

- A value that isn't even that
- The default value for variables and parameters
- The value of missing members in objects

Falsy values

- **`false`**
- **`null`**
- **`undefined`**
- **`""`** (empty string)
- **`0`**
- **`NaN`**

- All other values (including all objects) are truthy.

`"0"` **`"false"`**

Everything Else Is Objects

Dynamic Objects

- Unification of Object and Hashtable
- **`new Object()`** produces an empty container of name/value pairs
- A name can be any string, a value can be any value except **`undefined`**
- members can be accessed with dot notation or subscript notation
- No hash nature is visible (no hash codes or rehash methods)

Loosely Typed

- Any of these types can be stored in an variable, or passed as a parameter to any function

- The language is not "untyped"

C

- JavaScript is syntactically a C family language

- It differs from C mainly in its type system, which allows functions to be values

Identifiers

- Starts with a letter or _ or **$**
- Followed by zero or more letters, digits, _ or **$**

- By convention, all variables, parameters, members, and function names start with lower case
- Except for constructors which start with upper case

- Initial _ should be reserved for implementations
- **$** should be reserved for machines.

Reserved Words

abstract
boolean **break** byte
case catch char class const **continue**
debugger **default delete do** double
else enum export extends
false final **finally** float **for function**
goto
if implements import **in instanceof** int
interface
long
native **new null**
package private protected public
return
short static super **switch** synchronized
this throw throws transient **true try typeof**
var volatile **void**
while with

Comments

```
// slashslash line comment

/*
    slashstar
    block
    comment
*/
```

Operators

- Arithmetic

  `+ - * / %`

- Comparison

  `== != < > <= >=`

- Logical

  `&& || !`

- Bitwise

  `& | ^ >> >>> <<`

- Ternary

  `?:`

+

- Addition and concatenation
- If both operands are numbers,

  then

    add them

  else

    convert them both to strings

    concatenate them

'$' + 3 + 4 = '$34'

+

- Unary operator can convert strings to numbers

```
+"42" = 42
```

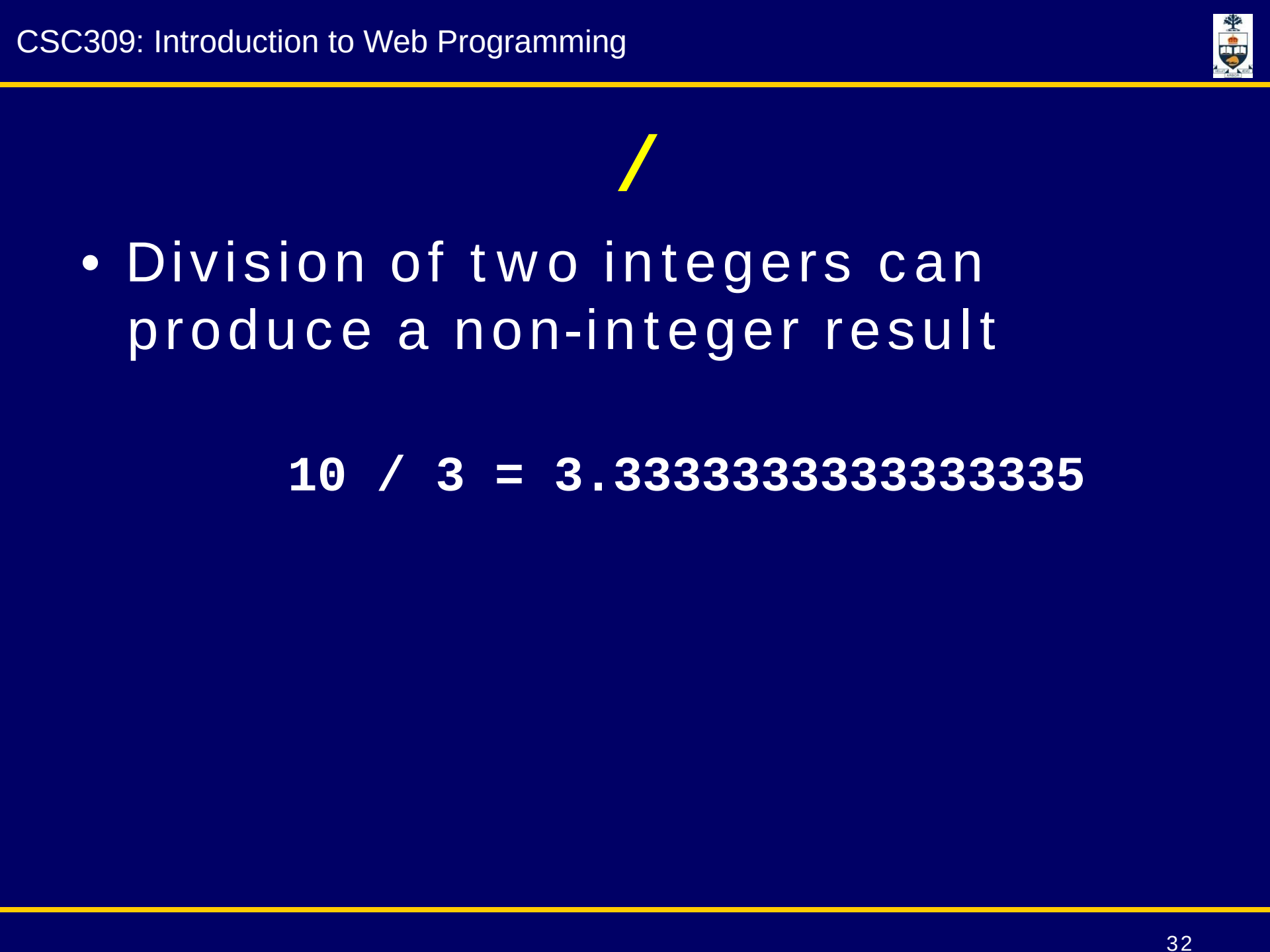
- Also

```
Number("42") = 42
```

- Also

```
parseInt("42", 10) = 42
```

```
+"3" + (+"4") = 7
```



/

- Division of two integers can produce a non-integer result

```
10 / 3 = 3.3333333333333335
```

== !=

- Equal and not equal
- These operators can do type coercion
- It is better to use === and !==, which do not do type coercion.

&&

- The guard operator, aka *logical and*
- If first operand is truthy
  then result is second operand
  else result is first operand

```
if (a) {
  return a.member;
} else {
  return a;
}
```

can be written as

```
return a && a.member;
```

- The default operator, aka *logical or*
- If first operand is truthy
  then result is first operand
  else result is second operand
- It can be used to fill in default values.

```
var last = input || nr_items;
```

- (If **`input`** is truthy, then **`last`** is input, otherwise set **`last`** to **`nr_items`**.)

`!`

- Prefix *logical not* operator.
- If the operand is truthy, the result is **`false`**. Otherwise, the result is **`true`**.
- `!!` produces booleans.

Bitwise

& | ^ >> >>> <<

- The bitwise operators convert the operand to a 32-bit signed integer, and turn the result back into 64-bit floating point.

Statements

- *expression*
- **if**
- **switch**
- **while**
- **do**
- **for**
- **break**
- **continue**
- **return**
- **try/throw**

Break statement

- Statements can have labels.
- Break statements can refer to those labels.

```
loop: for (;;) {
   …
      if (...) {
         break loop;
      }
   …
}
```

For statement

- Iterate through all of the elements of an array:

```
for (var i = 0; i < array.length; i += 1) {

    // within the loop,
    // i is the index of the current member
    // array[i] is the current element

}
```

For statement

- Iterate through all of the members of an object:

```
for (var name in object) {
    if (object.hasOwnProperty(name)) {

        // within the loop,
        // name is the key of current member
        // object[name] is the current value

    }
}
```

Switch statement

- Multiway branch
- The switch value does not need to a number. It can be a string.
- The case values can be expressions.

Switch statement

```
switch (expression) {
case ';':
case ',':
case '.':
    punctuation();
    break;
default:
    noneOfTheAbove();
}
```

Throw statement

```
throw new Error(reason);

throw {
    name: exceptionName,
    message: reason
};
```

Try statement

```
try {
    ...
} catch (e) {
    switch (e.name) {
    case 'Error':
        ...
        break;
    default:
        throw e;
    }
}
```

Try Statement

- The JavaScript implementation can produce these exception names:
  - **`'Error'`**
  - **`'EvalError'`**
  - **`'RangeError'`**
  - **`'SyntaxError'`**
  - **`'TypeError'`**
  - **`'URIError'`**

With statement

- Intended as a short-hand
- Ambiguous
- Error-prone
- Don't use it

```
with (o) {
    foo = null;
}
```

- `o.foo = null;`
- `foo = null;`

Function statement

```
function name(parameters) {
  statements;
}
```

Var statement

- Defines variables within a function.
- Types are not specified.
- Initial values are optional.

```
var name;
var nrErrors = 0;
var a, b, c;
```

Scope

- In JavaScript, {blocks} do not have scope.
- Only functions have scope.
- Vars defined in a function are not visible outside of the function.

Return statement

return *expression*;

- or

return;

- If there is no *expression*, then the return value is **undefined**.
- Except for constructors, whose default return value is **this**.

Objects

- Everything else is objects
- Objects can contain data and methods
- Objects can inherit from other objects.

Collections

- An object is an unordered collection of name/value pairs
- Names are strings
- Values are any type, including other objects
- Good for representing records and trees
- Every object is a little database

Object Literals

- Object literals are wrapped in **{ }**
- Names can be names or strings
- Values can be expressions
- **:** separates names and values
- **,** separates pairs
- Object literals can be used anywhere a value can appear

Object Literals

```
var myObject = {name: "Jack B. Nimble",
'goto': 'Jail', grade: 'A', level: 3};
```

"name"	"Jack B. Nimble"
"goto"	"Jail"
"grade"	"A"
"level"	3

```
var theName = myObject.name;
var destination = myObject['goto'];
```

Maker Function

```
function maker(name, where, grade, level) {
    var it = {};
    it.name = name;
    it['goto'] = where;
    it.grade = grade;
    it.level = level;
    return it;
}

myObject = maker("Jack B. Nimble",
    'Jail', 'A', 3);
```

Object Literals

```
var myObject = {name: "Jack B. Nimble",
'goto': 'Jail', grade: 'A', format:
{type: 'rect', width: 1920, height: 1080,
interlace: false, framerate: 24}};
```

Object Literals

```
var myObject = {
    name: "Jack B. Nimble",
    'goto': 'Jail',
    grade: 'A',
    format: {
        type: 'rect',
        width: 1920,
        height: 1080,
        interlace: false,
        framerate: 24
    }
};
```

Object Literals

```
myFunction({
    type: 'rect',
    width: 1920,
    height: 1080
});
throw {
    name: 'error',
    message: 'out of bounds'
};
```

Object Literals

```
function SuperDiv(width, height,
  left, top, zIndex, position,
  color, visibility, html,
  cssClass)

function SuperDiv(spec)
```

Object Augmentation

- New members can be added to any object by simple assignment

- There is no need to define a new class

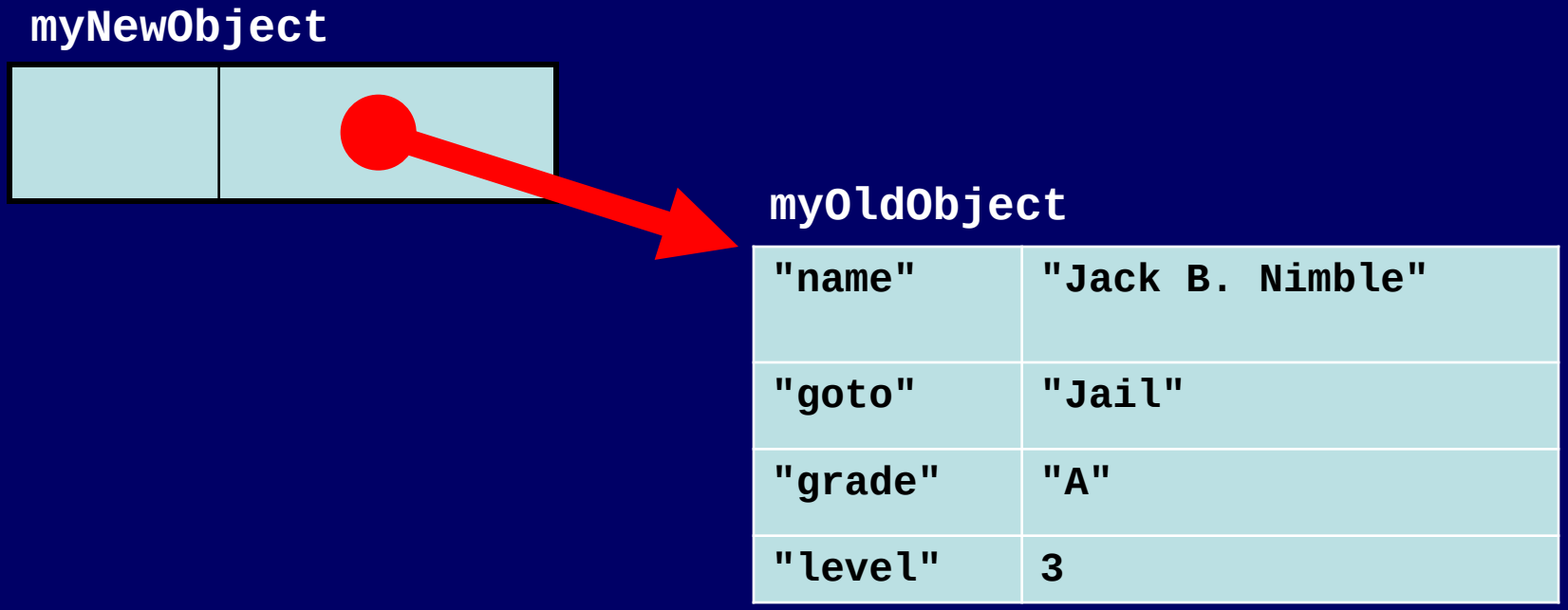
```
myObject.format.colorModel =
   'YCgCb';

myObject[name] = value;
```

Linkage

- Objects can be created with a secret link to another object.
- If an attempt to access a name fails, the secret linked object will be used.
- The secret link is not used when storing. New members are only added to the primary object.
- The **`object(`**o**`)`** function makes a new empty object with a link to object o.

Linkage

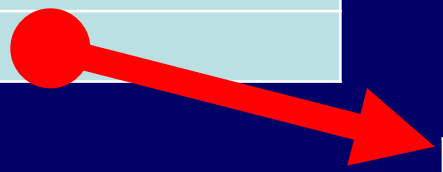
```
var myNewObject = object(myOldObject);
```



Linkage

```
myNewObject.name = "Tom Piperson";
myNewObject.level = myNewObject.level + 1;
myNewObject.crime = 'pignapping';
```

"name"	"Tom Piperson"
"level"	4
"crime"	"pignapping"



"name"	"Jack B. Nimble"
"goto"	"Jail"
"grade"	"A"
"level"	3

Inheritance

- Linkage provides simple inheritance.
- An object can inherit from an older object.

Prototypal Inheritance

- Some languages have classes, methods, constructors, and modules. JavaScript's functions do the work of all of those.
- Instead of Classical Inheritance, JavaScript has Prototypal Inheritance.
- It accomplishes the same things, but differently.
- It offers greater expressive power.
- But it's different.

Prototypal Inheritance

- Instead of organizing objects into rigid classes, new objects can be made that are similar to existing objects, and then customized.
- Object customization is a lot less work than making a class, and less overhead, too.
- One of the keys is the **`object(o)`** function.
- The other key is functions.

Object Methods

- All objects are linked directly or indirectly to **`Object.prototype`**
- All objects inherit some basic methods.
- None of them are very useful.
- **`hasOwnProperty(`**name**`)`**

  Is the name a true member of this object?
- No **`copy`** method.
- No **`equals`** method.

Object Construction

- Make a new empty object
- All three of these expressions have exactly the same result:

```
new Object()

{}

object(Object.prototype)
```

- `{}` is the preferred form.

Reference

- Objects can be passed as arguments to functions, and can be returned by functions
  - Objects are passed by reference.
  - Objects are not passed by value.
- The `===` operator compares object references, not values
  - **`true`** only if both operands are the same object

Delete

- Members can be removed from an object with the **delete** operator

```
delete myObject[name];
```

Arrays

- **`Array`** inherits from **`Object`**.
- Indexes are converted to strings and used as names for retrieving values.
- Very efficient for sparse arrays.
- Not very efficient in most other cases.
- One advantage: No need to provide a length or type when creating an array.

length

- Arrays, unlike objects, have a special **length** member.
- It is always 1 larger than the highest integer subscript.
- It allows use of the traditional **for** statement.

```
for (i = 0; i < a.length; i += 1) {
    …
}
```

- Do not use **for**..**in** with arrays

Array Literals

- An array literal uses **[]**
- It can contain any number of expressions, separated by commas

```
myList = ['oats', 'peas', 'beans'];
```

- New items can be appended

```
myList[myList.length] = 'barley';
```

- The dot notation should not be used with arrays.
- **[]** is preferred to **new Array()**.

Array Methods

- `concat`
- `join`
- `pop`
- `push`
- `slice`
- `sort`
- `splice`

Deleting Elements

`delete array[index]`

- Removes the element, but leaves a hole in the numbering.

```
array.splice(index, 1)
```

- Removes the element and renumbers all the following elements.

Deleting Elements

```
myArray = ['a', 'b', 'c', 'd'];

delete myArray[1];

// ['a', undefined, 'c', 'd']

myArray.splice(1, 1);

// ['a', 'c', 'd']
```

Arrays v Objects

- Use objects when the names are arbitrary strings.
- Use arrays when the names are sequential integers.
- Don't get confused by the term Associative Array.

Arrays and Inheritance

- Don't use arrays as prototypes.
  - The object produced this way does not have array nature. It will inherit the array's values and methods, but not its **`length`**.
- You can augment an individual array.
  - Assign a method to it.
  - This works because arrays are objects.
- You can augment all arrays.
  - Assign methods to **`Array.prototype`**

Functions

- Functions are first-class objects

1. Functions can be passed, returned, and stored just like any other value

2. Functions inherit from **`Object`** and can store name/value pairs.

Function operator

- The function operator takes an optional name, a parameter list, and a block of statements, and returns a function object.

```
function name(parameters) {
    statements
}
```

- A function can appear anywhere that an expression can appear.

lambda

- What JavaScript calls **`function`**, other languages call **`lambda`**.
- It is a source of enormous expressive power.
- Unlike most power-constructs, it is secure.

Function statement

- The function statement is just a short-hand for a **var** statement with a function value.

```
function foo() {}
```

expands to

```
var foo = function foo() {};
```

Inner functions

- Functions do not all have to be defined at the top level (or left edge).

- Functions can be defined inside of other functions.

Scope

- An inner function has access to the variables and parameters of functions that it is contained within.

- This is known as Static Scoping or Lexical Scoping.

Closure

- The scope that an inner function enjoys continues even after the parent functions have returned.

- This is called *closure*.

Example

```
function fade(id) {
    var dom = document.getElementById(id),
        level = 1;
    function step () {
        var h = level.toString(16);
        dom.style.backgroundColor =
            '#FFFF' + h + h;
        if (level < 15) {
            level += 1;
            setTimeout(step, 100);
        }
    }
    setTimeout(step, 100);
}
```

Function Objects

- Functions are objects, so they can contain name/value pairs.

- This can serve the same purpose as **`static`** members in other languages.

Method

- Since functions are values, functions can be stored in objects.

- A function in an object is called a *method*.

Invocation

- If a function is called with too many arguments, the extra arguments are ignored.
- If a function is called with too few arguments, the missing values will be **`undefined`**.
- There is no implicit type checking on the arguments.

Invocation

- There are four ways to call a function:
  - Function form
    - *functionObject*(*arguments*)
  - Method form
    - *thisObject*.*methodName*(*arguments*)
    - *thisObject*["*methodName*"](*arguments*)
  - Constructor form
    - **new** *functionObject*(*arguments*)
  - Apply form
    - *functionObject*.**apply**(*thisObject*, [*arguments*])

Method form

thisObject.*methodName*(*arguments*)

- When a function is called in the method form, **`this`** is set to *thisObject*, the object containing the function.
- This allows methods to have a reference to the object of interest.

Function form

functionObject(*arguments*)

- When a function is called in the function form, **`this`** is set to the global object.

  That is not very useful.

  It makes it harder to write helper functions within a method because the helper function does not get access to the outer **`this`**.

```
var that = this;
```

Constructor form

new *functionObject*(*arguments*)

- When a function is called with the **new** operator, a new object is created and assigned to **this**.
- If there is not an explicit return value, then **this** will be returned.

this

- **this** is an extra parameter. Its value depends on the calling form.
- **this** gives methods access to their objects.
- **this** is bound at invocation time.

Invocation form	**this**
function	the global object
method	the object
constructor	the new object

arguments

- When a function is invoked, in addition to its parameters, it also gets a special parameter called **`arguments`**.
- It contains all of the arguments from the invocation.
- It is an array-like object.
- **`arguments.length`** is the number of arguments passed.

Example

```
function sum() {
    var i,
        n = arguments.length,
        total = 0;
    for (i = 0; i < n; i += 1) {
        total += arguments[i];
    }
    return total;
}
```

Augmenting Built-in Types

- **`Object.prototype`**
- **`Array.prototype`**
- **`Function.prototype`**
- **`Number.prototype`**
- **`String.prototype`**
- **`Boolean.prototype`**

trim

```
String.prototype.trim = function () {
    return this.replace(
        /^\s*(\S*(\s+\S+)*)\s*$/, "$1");
};
```

typeof

- The **typeof** prefix operator returns a string identifying the type of a value.

type	typeof
object	'object'
function	'function'
array	'object'
number	'number'
string	'string'
boolean	'boolean'
null	'object'
undefined	'undefined'

eval

eval(*string***)**

- The **eval** function compiles and executes a string and returns the result.
- It is what the browser uses to convert strings into actions.
- It is the most misused feature of the language.

Function function

new Function(*parameters***, *body*)**

- The **Function** constructor takes zero or more parameter name strings, and a body string, and uses the JavaScript compiler to produce a function object.
- It should only be used to compile fresh source from a server.
- It is closely related to **eval**.

Built-in Type Wrappers

- Java has **`int`** and **`Integer`**, two incompatible types which can both carry the same value with differing levels of efficiency and convenience.

- JavaScript copied this pattern to no advantage. Avoid it.
- Avoid **`new Boolean()`**
- Avoid **`new String()`**
- Avoid **`new Number()`**

(global) Object

- The object that dares not speak its name.
- It is the container for all global variables and all built-in objects.
- Sometimes **`this`** points to it.

```
var global = this;
```

- On browsers, **`window`** is the global object.

Global variables are evil

- Functions within an application can clobber each other.
- Cooperating applications can clobber each other.
- Use of the global namespace must be minimized.

Implied Global

- Any var which is not properly declared is assumed to be global by default.
- This makes it easy for people who do not know or care about encapsulation to be productive, but it makes applications less reliable.
- JSLint is a tool which helps identify implied globals and other weaknesses.

http://www.JSLint.com

Namespace

- Every object is a separate namespace.
- Use an object to organize your variables and functions.
- The **YAHOO** Object.

```
<head>
<script>
YAHOO={};
</script>
```

- **http://twiki.corp.yahoo.com/view/Devel/TheYAHOOObject**

Thinking about type

- Trading type-safety for dynamism.
- JavaScript has no cast operator.
- Reflection is really easy, and usually unnecessary.
- Why inheritance?
  - Automatic casting
  - Code reuse
- Trading brittleness for flexibility.

RegExp

- Regular expression pattern matcher
- Patterns are enclosed in slashes
- Example: a pattern that matches regular expressions

```
/\/(\\[^\x00-\x1f]|\[(\\[^\x00-\x1f]|[^\x00-
\x1f\\\/])*\]|[^\x00-\x1f\\\/\[])+\/[gim]*/
```

- Bizarre notation, difficult to read.

Threads

- The language definition is neutral on threads
- Some language processors (like SpiderMonkey) provide thread support
- Most application environments (like browsers) do not provide it
- Threads are evil

Code Conventions for the JavaScript Programming Language

http://javascript.crockford.com/code.html

Semicolon insertion

- When the compiler sees an error, it attempts to replace a nearby linefeed with a semicolon and try again.
- This should alarm you.
- It can mask errors.
- Always use the full, correct forms, including semicolons.

Comma

- Avoid tricky expressions using the comma operators.
- Do not use extra commas in array literals.
- Good: `[1, 2, 3]`
- Bad: `[1, 2, 3,]`

Required Blocks

- Good:

```
if (a) {
    b();
}
```

- Bad:

```
if (a) b();
```

Forbidden Blocks

- Blocks do not have scope in JavaScript.

- Blocks should only be used with structured statements

```
function
if
switch
while
for
do
try
```

Variables

- Define all variables at the beginning of the function.

- JavaScript does not have block scope, so their is no advantage in declaring variables at the place of their first use.

Expression Statements

- Any expression can be used as a statement. That can mask errors.

- Only assignment expressions and invocation expressions should be used as statements.

- Good:

```
foo();
```

- Bad:

```
foo && foo();
```

`switch` Statement

- Avoid using fallthrough.
- Each clause should explicitly **`break`** or **`return`** or **`throw`**.

Assignment Expressions

- Do not use assignment expressions in the condition parts of **`if`**, **`while`**, or **`for`**.

- It is more likely that

```
if (a = b) { ... }
```

- was intended to be

```
if (a == b) { ... }
```

- Avoid tricky expressions.

== and !=

- Be aware that == and != do type coercion.
- Bad

```
if (a == null) { ... }
```

- Good:

```
if (a === null) { ... }
if (!a) { ... }
```

Labels

- Use labels only on these statements:
  - **`do`**
  - **`for`**
  - **`switch`**
  - **`while`**
- Never use **`javascript:`** as a label.

JSLint

- JSLint can help improve the robustness and portability of your programs.
- It enforces style rules.
- It can spot some errors that are very difficult to find in debugging.
- It can help eliminate implied globals.
- Currently available on the web and as a Konfabulator widget.
- Soon, in text editors and Eclipse.

http://www.JSLint.com/