



ID1354

Internet Applications

JavaScript

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Overview of JavaScript



- Originally developed by Netscape, as **LiveScript**
- Became a joint venture of **Netscape and Sun** in 1995, renamed JavaScript
- Now **standardized** by ECMA as ECMA-262, ECMAScript.
- The only relationship between JavaScript and Java is similar **syntax**.

Overview of JavaScript (Cont'd)

- JavaScript is the language for **client-side behavior** in web applications.
- Can **change HTML** documents using the Document Object Model, DOM.
- Can communicate with server using for example AJAX.
- Also becoming more used at the server side. This is not covered in the course.

How to Include JavaScript Code

- Write JavaScript in **separate files**, with the extension **.js**
- Include a JavaScript file with the **src attribute** of the **<script> element** in the HTML file that uses the JavaScript code:

```
<script src = "my-script.js"></script>
```
- Possible to write JavaScript code directly in the script tag, but that gives bad cohesion.

When is a Script Executed?

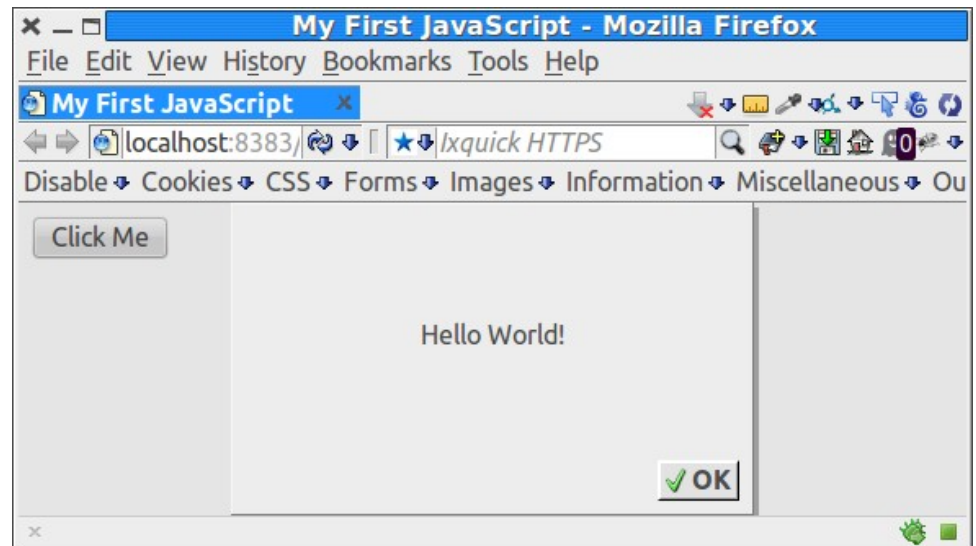
```
<script src="myScript" async defer></script>
```

- If the **async** attribute is specified, and the script is external (there is a **src** attribute), the script is executed **while the browser continues to parse** the HTML document.
- If the **async** attribute is not specified, but the **defer** attribute is, and the script is external (there is a **src** attribute), the script is executed **when the browser has finished parsing** the HTML document.
- If neither **async** nor **defer** attribute is specified, the script is fetched and executed immediately, **before the browser continues parsing** the HTML document.

The First Example

```
<!DOCTYPE html>
<html>
  <head>
    <title>My First JavaScript</title>
    <meta charset="UTF-8">
    <script src="hello-world.js"></script>
  </head>
  <body>
    <button type="button" onclick="greeting()">Click Me</button>
  </body>
</html>
```

```
function greeting() {
  alert("Hello World!");
}
```



Syntax

- **Identifiers** begin with a letter or underscore, followed by any number of letters, underscores, and digits.
- **Case sensitive**
- Statements are separated with **semicolon**.
- **Reserved words are:** abstract, arguments, boolean, break, byte, case, catch, char, class, const, continue, debugger, default, delete, do, double, else, enum, eval, export, extends, false, final, finally, float, for, function, goto, if, implements, import, in, instanceof, int, interface, let, long, native, new, null, package, private, protected, public, return, short, static, super, switch, synchronized, this, throw, throws, transient, true, try, typeof, var, void, volatile, while, with, yield
- **Comments:** single-line, `//`, and multiple-line, `/* some comment */`

Code Conventions

- Always use **the same naming convention** for all your code, preferably similar to Java:
 - **Variable and function** names written as camelCase.
 - **Global variables** written in UPPERCASE.
 - **Constants** (like PI) written in UPPERCASE
- Write **declarations at the beginning** of the scope.

Strict Mode

- A restricted variant of JavaScript, with different semantics from normal code.
 - Prohibits some syntax, for example assignment to undeclared variable.
 - Eliminates some JavaScript silent errors by changing them to throw errors.
 - Fixes mistakes that make it difficult for JavaScript engines to perform optimizations
- To apply strict mode, put the exact statement "use strict"; (or 'use strict';) before any other statements.

Variables

- JavaScript is **dynamically typed**, type is **never declared** and variables **change type** when needed.
`year = "in the eighties";` `year` is a **string**.
`year = 84;` `year` is a **number**.
- **Global variables** can be **declared** either **implicitly**, just write the variable name, or **explicitly**, variable name preceded with **var**.
`var sum = 0;`
`today = "Monday";`
`flag = false;`
- **Block scoped** variables are preceded with **let**.
`let sum = 0;`

Local Variables Must Be Declared With **let** (or **var**)

- Local variables must be explicitly declared with the **var** or **let** keyword.
- Here, c is a **local** variable.

```
function myFunction(a, b) {  
    let c = 4;  
    return a + b + c;  
}
```

- Here, c is a **global** variable. **Avoid** this kind of declaration.

```
function myFunction(a, b) {  
    c = 4;  
    return a + b + c;  
}
```

Hoisting

- JavaScript **hoists all declarations**, which means they are moved to the top of the current scope (function or script).
- However, **initializations** are not hoisted.

```
var x = 5;  
var sum = x + y;  
var y = 7;
```

is hoisted to

```
var x;  
x = 5;  
var y;  
var sum = x + y;  
y = 7;
```

which does not make sense since **y has no value** when it is used.

- Always **write declarations at the beginning** of the scope, since that is how they are interpreted by JavaScript.

Primitive Values

- All primitive values have one of the five **primitive types**: **Number**, **String**, **Boolean**, **Undefined**, **Null**.
- **Number**, **String**, and **Boolean** have **wrapper objects** (**Number**, **String**, and **Boolean**), just like Java.
- For **Number** and **String**, primitive values and objects are **coerced** back and forth, therefore, primitive values can be **treated as objects**, for example:

```
var a = 10;  
var b = a.toString();
```

Strings

- String literals are **delimited** by either `'` or `"`.
- Quotes can be used inside strings if they don't match the quotes surrounding the string:

```
    "She is called 'Stina'";  
    'He is called "Pelle"';
```
- Strings can include **escape sequences**, e.g., `\t` or `\n`.
Note that these will not cause tabs or line breaks in a HTML page since they are not HTML tags.

Numbers

- Numbers can be **with or without decimals**:

const PI = 3;

const PI = 3.14;

- Numbers are represented in double-precision 64-bit format, meaning the range is

$\pm 1.7976931348623157e+308$ to $\pm 5e-324$

Boolean, Null, Undefined

- A **Boolean** can have the value **true** or **false**
- The only **Undefined** value is **undefined**. It is the value of a variable that has **never been set** to any value.
- The only **Null** value is **null**. It is used to **unset** a variable:

name = "Sara"; Name has the value **"Sara"**.

name = null; Name has the value **null**.

Assignment Operators

- Assignment operators are the same as in Java, `=`, `+=`, `-=`, etc

Bitwise Operators

- Bitwise operators are **and**, **&**; **or**, **|**; **not**, **~**; **xor**, **^**; **left shift**, **<<**; **right shift**, **>>**
- Bit operators work on 32 bits numbers.
- Any numeric operand in the operation is converted into a 32 bit number and the result is converted back to a JavaScript number.

Arithmetic Operators

- Numeric operators are the same as in Java, `++`, `--`, `+`, `-`, `*`, `/`, `%`
- All operations are in **double precision**.
- Same **precedence** and **associativity** as Java

Concatenation and Conversion

- The **string concatenation** operator is the same as in Java, **+**
- **Concatenation** coerces numbers to strings.
- **Numeric operators**, other than **+**, coerce strings to numbers.
- If either operand of **+** is a string, it becomes a concatenation operator.
- **Explicit conversions** are as follows:
 1. Use the **String** and **Number** constructors
 2. Use **toString** method:

```
var a = 10;  
a = a.toString();
```
 3. Use **parseInt** and **parseFloat** methods:

```
var a = "10";  
a = parseInt(a);
```

Question 1

Number Utilities

- The **Math object** provides functions like **floor**, **round**, **max**, **min**, trigonometric functions, etc
- The **Number object** has useful properties like **MAX_VALUE**, **MIN_VALUE**, **POSITIVE_INFINITY**, **NEGATIVE_INFINITY**, **PI** and **NaN**.
 - **NaN** represents an illegal number, for example the result of an overflow.
 - It is not equal to any other number, not even itself. Test for it with the **isNaN()** function.

Typeof Operator

- The **typeof** operator returns the **type** of a variable or expression.
- It returns **"number"**, **"string"**, or **"boolean"** for Number, String, or Boolean, **"undefined"** for Undefined, **"function"** for a function, **"object"** for objects, and **"object"** also for **null**

typeof 10 returns the string **"number"**

The Date Object

- The **Date** Object

- Create one with the **Date** constructor (no params)

- Local time methods of **Date**:

- toLocaleString** - returns a string of the date

- getDate** - returns the day of the month

- getMonth** - returns the month of the year (0 - 11)

- getDay** - returns the day of the week (0 - 6)

- getFullYear** - returns the year

- getTime** - returns the number of milliseconds since Jan 1, 1970

- getHours** - returns the hour (0 - 23)

- getMinutes** - returns the minutes (0 - 59)

- getMilliseconds** - returns the millisecond (0 - 999)

- Example: **new Date().getDate();**

The `String` Object

- Some `String` properties and methods:

- `length` e.g., `var len = str1.length;` (a property, not a function)
- `charAt(position)` the char at the specified pos, e.g., `str.charAt(3)`
- `indexOf(string)` the pos of the specified string, e.g., `str.indexOf('B')`
- `substring(from, to)` the specified substring, e.g., `str.substring(1, 3)`
- `toLowerCase()` e.g., `str.toLowerCase()`

Output using the **Document** Object

- The **document** object represents the current **HTML Document**, an **Element** object represents a **HTML element**.
 - The **document** object is always present in a HTML page.
- The following line returns the HTML element with id **elemid**:
`document.getElementById("elemid");`
- The following line sets the HTML code of the element with id **elemid**:
`document.getElementById("demo").innerHTML =
"Some output
";`

Output Using the Console

- The **console** object has methods for writing to the **JavaScript console**, for example **console.log("a message");**
- This is useful when debugging a JavaScript program.
- Javascript errors are printed to the console.
- *Remember to check the console* if the program does not behave as expected.

IO Using the **alert**, **confirm** and **prompt** methods.

1. **alert("Hej! \n");**

- Parameter is plain text, not HTML
- Opens a dialog box which displays the **parameter string** and an **OK** button.

2. **confirm("Do you want to continue?");**

- Opens a dialog box and displays **the parameter** and two buttons, **OK** and **Cancel**.

3. **prompt("What is your name?", "");**

- Opens a dialog box and displays its string **parameter**, along with a text box and two buttons, **OK** and **Cancel**
- The second parameter is for a default response if the user presses **OK** without typing a response in the text box.

Control Statements

- **if** statements, **for** loops and **while** loops are similar to Java.
- There are three kinds of conditions: primitive values, relational expressions and compound expressions.

1. Primitive values

- If it is a string, it is **true** unless it is the empty string.

if ("hej") enters the if block.

if ("") does not enter the if block.

- If it is a number, it is **true** unless it is zero

Control Statements (Cont'd)

2. Relational Expressions

- The **usual** six **comparison** operators: ==, !=, <, >, <=, >=
- Operands are **coerced** if necessary
 - If one operand is a string and one is a number, the **string is coerced to a number**.
 - If one operand is a boolean and the other is not, the boolean is **coerced** to a number (1 or 0)
- The **unusual** two **comparison** operators: === and !==
 - Same as == and !=, except that **no coercions** are done. The expression can only be true if the operands have the **same type**.

Control Statements (Cont'd)

2. Relational Expressions (Cont'd)

- Comparisons of **references** to objects compare **addresses**, not values.

3. Compound Expressions

- The **logical operators** are: and, **&&**; or, **| |**; not, **!**
(x < 10 && y > 1)

Functions

- Functions are declared and prefixed with the **function** keyword, like in PHP.
- Since JavaScript is dynamically typed, neither parameters nor return value has a type:

```
function sum(a, b) {  
    return a + b;  
}
```


Anonymous Functions

- An **anonymous** function is defined in an **expression**, instead of a declaration.
- The **reference** to the anonymous function is **stored in a variable**, which can then be used to invoke the function.

```
let myFunc = function(a, b) {return a + b};  
myFunc(4, 3); //Returns 7
```

Function Hoisting

- Functions are hoisted the same way as variables, therefore, a function can be **called before it is declared**:

```
square(5);  
function square(y) {  
    return y * y;  
}
```

Function Parameters

- Parameters are **passed by value**, like in Java.
- The **number of arguments** is not checked.

Missing Arguments

- **Missing arguments** are set to **undefined**.
- If undefined variables are not desired, assign default values in the function:

```
function myFunction(x, y) {  
    if (y === undefined) {  
        y = 0; //default value  
    }  
    ...  
}
```

- Can also be written like this:

```
function myFunction(x, y) {  
    y = y || 0;  
    ...  
}
```

Extra Arguments

- **Extra arguments** have no name, but can be read from the **arguments** array, which is a built-in object:

```
x = sumAll(1, 123, 500, 115, 44);
```

```
function sumAll() {  
    let sum = 0;  
    for (let i=0; i<arguments.length;i++){  
        sum += arguments[i];  
    }  
    return sum;  
}
```

Question 2

Closures

- **Closures** are similar to php, but there is a subtle difference.
- In both languages, a variable declared in an outer function is associated with an inner function, and can be used in the inner function after the outer has terminated.
- In **JavaScript**, this association is **by reference**, which means the variable of the closure can change value at any time.
- Compare with **PHP**, where the association is **by value**, which means the closure uses the variable value when the inner function is created. The value can not be changed after that.

Arrays

- Arrays are normally created with the **array literal**:
`var myList = [24, "bread", true];`
- Elements are accessed by referring to **index** number, `myList[0]` has the value **24**. The first element is at index **0**.
- The **length** property is always set to the **number of elements** in the array.

Arrays (Cont'd)

- Elements can be **added**:

```
myList[myList.length] = "Stina";
```

- Elements can be **iterated** with a for-of loop:

```
let fruits = ["Banana", "Orange", "Apple"];  
for (let fruit of fruits) {  
    alert(fruit);  
}
```

Some Array Methods

- **join** Joins all elements of an array into a string.
- **sort** Coerces elements to strings and puts them in alphabetical order.
- **concat** Joins two or more arrays, and returns a copy of the joined arrays.
- **push** Appends elements to the end.
- **pop** Removes the last element.
- **unshift** Prepends elements to the beginning.
- **shift** Removes the first element.

The Object Model

- The object model is quite different from Java.
- JavaScript is prototype-based. An object has a prototype (another object), which in turn has a prototype, and so on all the way up to the object Object, whose prototype is null.
- An object contains its own properties, and the properties of its prototype.
- No classes, class-based inheritance, interfaces or polymorphism. These features can be mimicked, but they are not built-in as in Java.

Properties

- Like in Java, objects can have **properties** (variables).
- An object is a **collection of properties**, a bit like an array with named elements.
- Properties can be accessed the following ways:
objectName.property e.g., **person.age**
objectName["property"] e.g., **person["age"]**

Creating an Object With an Object Literal

- Specify a **list** with a **name:value** pair for each property. Such a list is called an **object literal**.

```
var person = {firstName : "Nisse", age : 3};
```

- An object literal is most appropriate when the object is used as a collection of data, without methods.

for-in loop

- Properties can be iterated with the for-in loop:

```
let person = {name:"Stina", age:57};  
for (let x in person) {  
    alert(x + ": " + person[x]);  
}
```

- Difference between **for-in** and **for-of** loop:
 - **for-in** iterates only over **enumerable properties** of an object.
 - **for-of** iterates over **all data** the iterable object defines to be iterated over.

Creating an Object With a Constructor

- A constructor is an **ordinary function**. Objects are created with the `new` keyword, much like in Java or PHP.

```
function Person(firstName, age) {  
  this.firstName = firstName;  
  this.age = age;  
}  
let myMother = new Person("Fia", 48);
```

- A constructor is more appropriate when the object is **not just a collection of data**.

How an Object is Created With a Constructor

- ```
function Person(firstName, age) {
 this.firstName = firstName;
 this.age = age;
}
let myMother = new Person("Fia", 48);
```
- What actually happens when the constructor is called is:
  1. The **new** operator **creates** an object.
  2. The created **object is passed** to the **Person** constructor as the value of **this**.
  3. The constructor **creates the properties **firstName** and **age**** in the object.
  4. The object's **reference is stored** in **myMother**.



# By Reference

- A variable that holds an object is a **reference** to that object.

```
let person = {firstName : "Nisse", age : 50};
let samePerson = person;
samePerson.age = 40; //Updates also person.
```

# Add and Delete Properties

- A Property is **added** by assigning a value to it.

```
let person = {firstName : "Stina", age : 50};
person.lastName = "Svensson";
```

- A Property is **deleted** with the keyword **delete**.

```
let person = {firstName : "Stina", age : 50};
delete person.age; //person.age is now
 //undefined.
```

# Methods

- Methods are **functions defined as properties**.
- Method calls have the same syntax as in Java, **`objectName.methodName()`** ;

# Defining Methods

- Methods can be defined in **constructors**.

```
function Person(firstname) {
 this.name = firstname;
 this.changeName = function(name) {
 this.name = name;
 }
}
```

```
let person = new Person("Olle");
person.changeName("Pelle");
```

- Like properties, methods can also be added with the object **literal** or added to **existing** objects.

# The **this** keyword

- In previous examples, **this** has been used like we would use it in Java.
- That is not a good practice, since **this** might point to **wrong object** when a method is called from an event handler, for example as a consequence of the user clicking a button.

# The **this** keyword

- A solution is to store **this** in a variable in the constructor.

```
function Person(firstname) {
 let self = this;
 self.name = firstname;
 self.changeName = function(name) {
 self.name = name;
 }
}
```

- Note the usage of a closure. **self** is used in the anonymous function stored in **changeName** after the function **Person** has terminated.

# Question 3

# Object Prototype

- An object has a **prototype**, and contains also its prototype's properties.
- The prototype **is also an object**.
- An object created from its own **constructor**, has the constructor as prototype.
- Objects created with the object **literal**, or with **new Object()**, has the **prototype of the object Object**.



# Prototype Chain

- Each object has a **prototype chain**, the top of which is **Object.prototype**.
- Objects contains properties from **all prototypes** in the prototype chain.
- When looking for a property, the **whole chain** is followed until the prototype is found or the top is reached.
  - This is **slow** for long chains.

# Inheritance

- To inherit an object, **set the prototype** to the object that shall be inherited:

```
function Person(name) {
 this.name = name;
}
```

```
function Employee(name, salary) {
 this.parent = Person;
 this.parent(name);
 this.salary = salary;
}
```

```
Employee.prototype = new Person();
```

```
let sara = new Employee("Sara", 1200);
```

# Inheritance (Cont'd)

- The **Employee** constructor from previous slide:

```
function Employee(name, salary) {
 this.parent = Person;
 this.parent(name);
 this.salary = salary;
}
```
- Assigning **Person** to the **parent** property means that property is actually **the Person function**.
- When **this.parent** is called, **Person** executes and **adds the name property** to the object indicated by **this**, namely the newly created **Employee** object.

# Inheritance (Cont'd)

- Much can be said about pros and cons of this and other ways to inherit.
- Much can also be said about implementing polymorphism and other object-oriented constructs.
- However, that is outside the scope of this course.

# Regular Expressions

- Both HTML and HTTP are **string based**.
- Web applications often contain a lot of code **searching and manipulating** strings.
- **Regular expressions** is a powerful tool for this.
- A regular expression is a sequence of characters that forms a **search pattern**.

# Regexp Syntax

- A regular expression has the form `/pattern/modifiers`, for example `/stina/i`.
  - The `i` modifier means the expression is case insensitive.
- Note that the regexp is not a string. In fact, it is a **RegExp** object.

## Methods Often Used for Regexp.

- The **search** and **replace** methods in the **string** object are good candidates for using regular expressions.

```
let str = "Hi, My name is Stina";
let n = str.search(/stina/i); //n is 15
```

```
let str = "Hi, my name is Olle";
let res = str.replace(/olle/i,
 "a secret");
//res is "Hi, my name is a secret"
```

# Regular Expression Characters

- There are **two categories of characters** in a regexp pattern:
  - **Metacharacters** have special meanings in patterns and do not match themselves. The following are metacharacters:  
`\ | ( ) [ ] { } ^ $ * + ? .`
  - **Normal characters** that do match themselves. All characters except the metacharacters are normal characters.
- A metacharacter is **treated** as a normal character if it is preceded by a backslash, `\`.



# Character Classes

- **[abc]** means **any** of the characters a, b or c.
- **[a-z]** means any character in the **range** a-z.
- A caret at the left end of a class definition means **not**.  
**[^0-9]** means any character not in the range 0-9
- The character **order** when defining ranges is the Unicode order.

# Predefined Character Classes

There are many [predefined](#) character classes with [abbreviations](#).

| <i>Abbr.</i> | <i>Equiv. Pattern</i> | <i>Matches</i>                |
|--------------|-----------------------|-------------------------------|
| <b>\d</b>    | <b>[0-9]</b>          | a digit                       |
| <b>\D</b>    | <b>[^0-9]</b>         | not a digit                   |
| <b>\w</b>    | <b>[A-Za-z_0-9]</b>   | a word character              |
| <b>\W</b>    | <b>[^A-Za-z_0-9]</b>  | not a word character          |
| <b>\s</b>    | <b>[\r\t\n\f]</b>     | a whitespace<br>character     |
| <b>\S</b>    | <b>[^\r\t\n\f]</b>    | not a whitespace<br>character |

# Quantifiers

| Quantifier | Meaning                                        |
|------------|------------------------------------------------|
| {n}        | exactly n occurrences of the preceding pattern |
| {m, }      | at least m occurrences                         |
| {m, n}     | at least m but not more than n occurrences     |
| +          | at least one occurrence                        |
| *          | any number of occurrences                      |
| ?          | zero or one occurrence                         |

# Anchors

- The pattern is forced to match only at the beginning with `^`  
`/^Lee/` matches "**Lee Ann**" but not "**Mary Lee Ann**"
- The pattern is forced to match only at the end with `$`  
`/Lee$/` matches "**Mary Lee**", but not "**Mary Lee Ann**"

# Handling Errors

- Error handling is done much the same way as in Java, using try-catch blocks.

```
try {
 // Block of code.
} catch(err) {
 // Handle errors from the try block.
}
```

# Throwing Exceptions

- The JavaScript interpreter will throw an **exception** if there is an **error in the code**.

- The first **alert** statement below throws an exception since **x** is not defined.

```
try {
 alert(x);
} catch (err) {
 alert(err);
}
```

- Exceptions can also be **thrown** with the **throw** statement. The exception can be a **String**, a **Number**, a **Boolean** or an **Object**:

```
throw "Error message";
```

# finally Block

- A **finally** block is always executed when leaving the try/catch blocks.

```
try {
 // Block of code.
} catch(err) {
 // Handle errors from the try block.
} finally {
 // Always executed.
}
```

# Best Practices

- **Avoid** using global variables.
- **Declare local variables** with the **let** keyword, to use block scope.
- Always treat numbers, strings, and booleans as **primitive values**, never as objects.
  - Objects are slower and comparisons may fail when mixing objects and primitives.
- Use **===** and **!==** instead of **==** and **!=**
  - 0 == ""** is true
  - 0 === ""** is false