JavaScript

4.1 Overview of JavaScript: Origins

- **Originally named LiveScript**
- **JavaScript was invented by Brendan Eich**
- **Originally developed by Netscape**
- **Joint Development with Sun Microsystems in 1995**
- **Version 1.0 to 1.8**
- **Standard 262 (ECMA-262) of the European Computer Manufacturers Association – approved by ISO as ISO16262**
- **ECMA-262 edition 3 is the current standard**
    - **Edition 4 is under development**
- **Supported by Netscape, Mozilla, Internet Explorer**
- **Microsoft JavaScript is named JScript**

4.1 JavaScript Components

- Core
  - The heart of the language
- Client-side
  - Library of objects supporting browser control and user interaction
- Server-side
  - Library of objects that support use in web servers

- Text focuses on Client-side

4.1 Java and JavaScript

- **Differences**
  - **JavaScript has a different object model from Java**
  - **JavaScript is not strongly typed**
  - **Variables in JavaScript need not be declared and are dynamically typed, making compile time type checking impossible**
  - **Objects in Java are static but in JavaScript objects are dynamic**
  - **Compiling and execution of JavaScript at the time document rendering.**

4.1 Uses of JavaScript

- **Provide alternative to server-side programming**
  - **Servers are often overloaded**
  - **Client processing has quicker reaction time**
- **JavaScript can work with forms**
- **JavaScript can interact with the internal model of the web page (Document Object Model)**
- **JavaScript is used to provide more complex user interface than plain forms with HTML/CSS can provide**

4.1 Event-Driven Computation

- **Users actions, such as mouse clicks and key presses, are referred to as *events***
- **The main task of most JavaScript programs is to respond to events**
- **For example, a JavaScript program could validate data in a form before it is submitted to a server**
  - ***Caution:* It is important that crucial validation be done by the server. It is relatively easy to bypass client-side controls**
  - **For example, a user might create a copy of a web page but remove all the validation code.**

4.1 XHTML/JavaScript Documents

- When JavaScript is embedded in an XHTML document, the browser must interpret it
- Two locations for JavaScript server different purposes
  - JavaScript in the head element will react to user input and be called from other locations
  - JavaScript in the body element will be executed once as the page is loaded
- Various strategies must be used to ‘protect’ the JavaScript from the browser
  - For example, comparisons present a problem since < and > are used to mark tags in XHTML
  - JavaScript code can be enclosed in XHTML comments

4.2 Object Orientation and JavaScript

- **JavaScript is *object-based***
  - **JavaScript defines objects that encapsulate both data and processing**
  - **However, JavaScript does not have true inheritance nor subtyping**
- **JavaScript provides *prototype-based inheritance***

4.2 JavaScript Objects

- **Objects are collections of *properties***
- **Properties are either *data properties* or *method properties***
- **Data properties are either primitive values or references to other objects**
- **Primitive values are often implemented directly in hardware**
- **The Object object is the ancestor of all objects in a JavaScript program**
    - **Object has no data properties, but several method properties**

4.3 JavaScript in XHTML

- **Directly embedded**

  ```
  <script type=“text/javascript”>
    <!--
      …Javascript here…
    -->
  </script>
  ```

  - **However, note that `a--` will not be allowed here!**

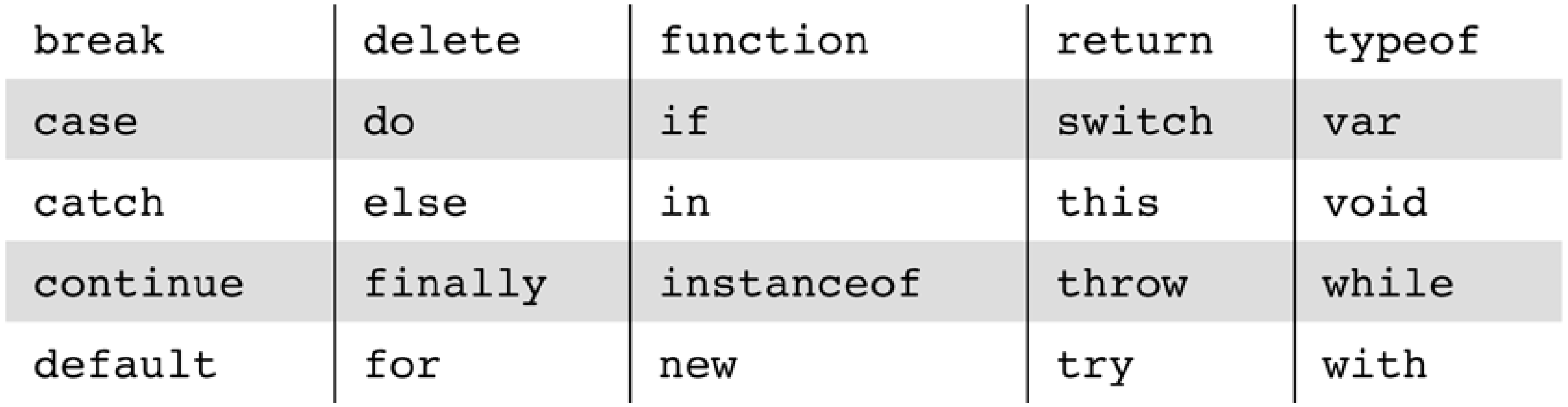
- **Indirect reference**

  ```
  <script type=“text/javascript” src=“tst_number.js”/>
  ```

  - **This is the preferred approach**

4.3 General Syntactic Characteristics

- **Reserved words**



break	delete	function	return	typeof
case	do	if	switch	var
catch	else	in	this	void
continue	finally	instanceof	throw	while
default	for	new	try	with

- **Comments**
  - **//**
  - **/* … */**

4.3 Statement Syntax

- Statements can be terminated with a semicolon
- However, the interpreter will insert the semicolon if missing at the end of a line and the statement seems to be complete
- Can be a problem:

```
return
x;
```

- If a statement must be continued to a new line, make sure that the first line does not make a complete statement by itself
- Example hello.html

4.4 Primitive Types

- Five primitive types
    - Number
    - String
    - Boolean
    - Undefined
    - Null
- There are five classes corresponding to the five primitive types
    - Wrapper objects for primitive values
    - Place for methods and properties relevant to the primitive types
    - Primitive values are *coerced* to the wrapper class as necessary, and vice-versa

4.4 Primitive and Object Storage

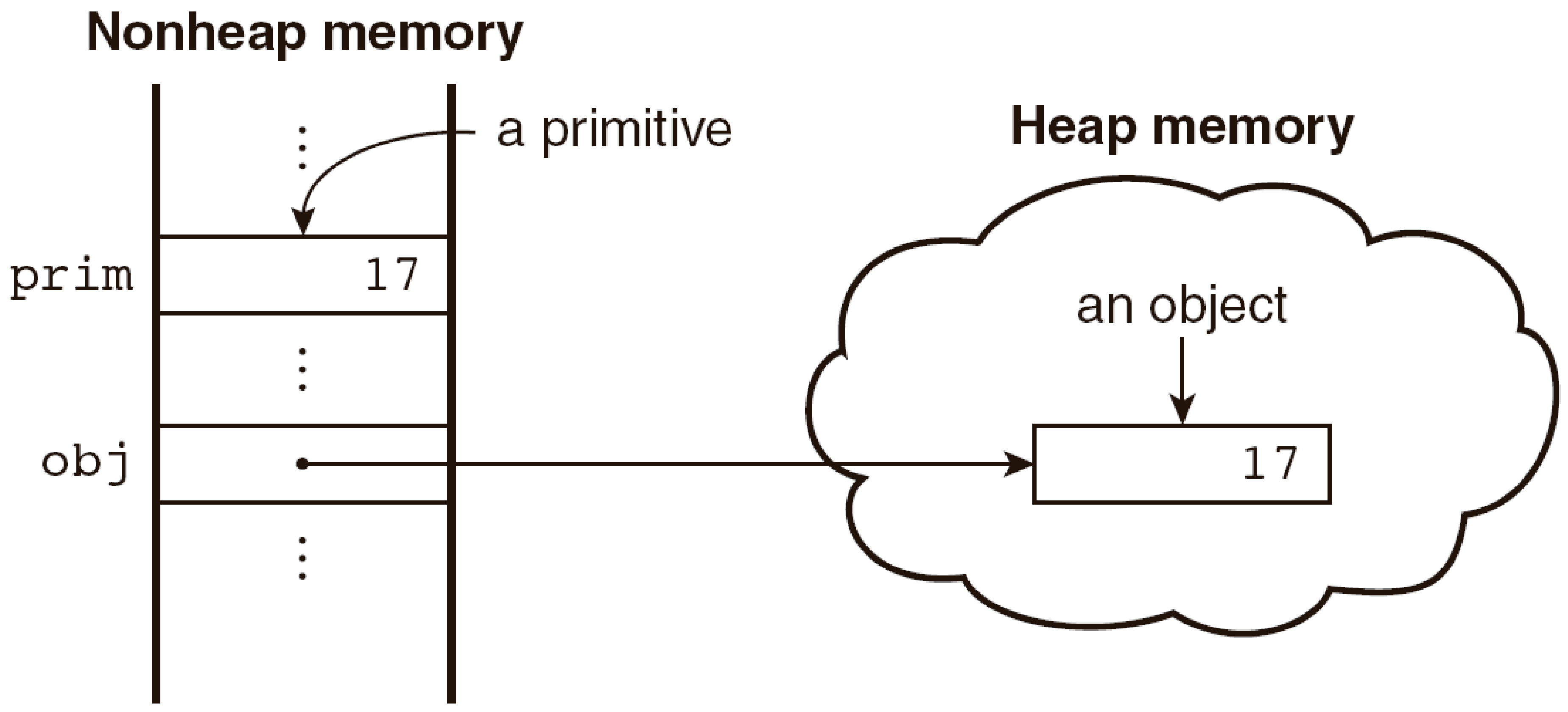


Figure 4.1 Primitives and objects

4.4 Numeric and String Literals

- **Number values are represented internally as double-precision floating-point values**
  - **Number literals can be either integer or float**
  - **Float values may have a decimal and/or and exponent**
- **A String literal is delimited by either single or double quotes**
  - **There is no difference between single and double quotes**
  - **Certain characters may be *escaped* in strings**
    - **\’ or \” to use a quote in a string delimited by the same quotes**
    - **\\ to use a literal backspace**
  - **The empty string ‘’ or “” has no characters**

4.4 Other Primitive Types

- Null
  - A single value, null
  - `null` is a reserved word
  - A variable that is used but has not been declared nor been assigned a value has a null value
  - Using a null value usually causes an error
- Undefined
  - A single value, undefined
  - However, undefined is not, itself, a reserved word
  - The value of a variable that is declared but not assigned a value
- Boolean
  - Two values: true and false

4.4 Declaring Variables

- **JavaScript is *dynamically typed*, that is, variables do not have declared types**
  - **A variable can hold different types of values at different times during program execution**
- **A variable is declared using the keyword var**

```
var counter,
index,
pi = 3.14159265,
quarterback = "Elway",
stop_flag = true;
```

4.4 Numeric Operators

- **Standard arithmetic**
  - `+   *   -   /   %`
- **Increment and decrement**
  - `--    ++`
  - **Increment and decrement differ in effect when used before and after a variable**
  - **Assume that `a` has the value 3, initially**
  - `(++a) * 3` **has the value 24**
  - `(a++) * 3` **has the value 27**
  - `a` **has the final value 8 in either case**

4.4 Precedence of Operators

Operators	Associativity
`++, --,` unary `-`	Right
`*, /, %`	Left
`+, -`	Left
`>, <, >= ,<=`	Left
`==, !=`	Left
`===,!==`	Left
`&&`	Left
`||`	Left
`=, +=, -=, *=, /=, &&=, ||=, %=`	Right

4.4 Example of Precedence

```
var a = 2,
b = 4,
c,
d;
c = 3 + a * b;
// * is first, so c is now 11 (not 24)
d = b / a / 2;
// / associates left, so d is now 1 (not 4)
```

4.4 The `Math` Object

- **Provides a collection of properties and methods useful for Number values**
- **This includes the trigonometric functions such as `sin` and `cos`**
- **When used, the methods must be qualified, as in `Math.sin(x)`**

4.4 The `Number` Object

- Properties
  - `MAX_VALUE`
  - `MIN_VALUE`
  - `NaN`
  - `POSITIVE_INFINITY`
  - `NEGATIVE_INFINITY`
  - `PI`
- Operations resulting in errors return `NaN`
  - Use `isNaN(a)` to test if a is `NaN`
- toString method converts a number to string

4.4 String Catenation

- **The operation + is the string catenation operation**
- **In many cases, other types are automatically converted to string**

4.4 Implicit Type Conversion

- **JavaScript attempts to convert values in order to be able to perform operations**
- **“August “ + 1977 causes the number to be converted to string and a concatenation to be performed**
- **7 * “3” causes the string to be converted to a number and a multiplication to be performed**
- **null is converted to 0 in a numeric context, undefined to NaN**
- **0 is interpreted as a Boolean false, all other numbers are interpreted a true**
- **The empty string is interpreted as a Boolean false, all other strings (including “0”!) as Boolean true**
- **undefined, Nan and null are all interpreted as Boolean false**

4.4 Explicit Type Conversion

- Explicit conversion of string to number
  - Number(aString)
  - aString – 0
  - Number must begin the string and be followed by space or end of string
- parseInt and parseFloat convert the beginning of a string but do not cause an error if a non-space follows the numeric part

4.4 `String` Properties and Methods

- **One property: length**
  - **Note to Java programmers, this is not a method!**
- **Character positions in strings begin at index 0**

4.4.11 String Methods

Method	Parameters	Result
charAt	A number	Returns the character in the String object that is at the specified position
indexOf	One-character string	Returns the position in the String object of the parameter
substring	Two numbers	Returns the substring of the String object from the first parameter position to the second
toLowerCase	None	Converts any uppercase letters in the string to lowercase
toUpperCase	None	Converts any lowercase letters in the string to uppercase

4.4 The `typeof` Operator

- **Returns "number" or "string" or "boolean" for primitive types**
- **Returns "object" for an object or null**
- **Two syntactic forms**
  - `typeof x`
  - `typeof(x)`

4.4 Assignment Statements

- **Plain assignment indicated by =**
- **Compound assignment with**
  - `+=      -=      /=      *=    %=    …`
- **a += 7 means the same as**
- **a = a + 7**

4.4 The Date Object

- A Date object represents a *time stamp*, that is, a point in time
- A Date object is created with the new operator
    - var now= new Date();
    - This creates a Date object for the time at which it was created

4.4 The `Date` Object: Methods

toLocaleString	A string of the Date information
getDate	The day of the month
getMonth	The month of the year, as a number in the range of 0 to 11
getDay	The day of the week, as a number in the range of 0 to 6
getFullYear	The year
getTime	The number of milliseconds since January 1, 1970
getHours	The number of the hour, as a number in the range of 0 to 23
getMinutes	The number of the minute, as a number in the range of 0 to 59
getSeconds	The number of the second, as a number in the range of 0 to 59
getMilliseconds	The number of the millisecond, as a number in the range of 0 to 999

4.5 Window and Document

- **The Window object represents the window in which the document containing the script is being displayed**
- **The Document object represents the document being displayed using DOM**
- **Window has two properties**
  - **`window` refers to the Window object itself**
  - **`document` refers to the Document object**
- **The Window object is the default object for JavaScript, so properties and methods of the Window object may be used without qualifying with the class name**

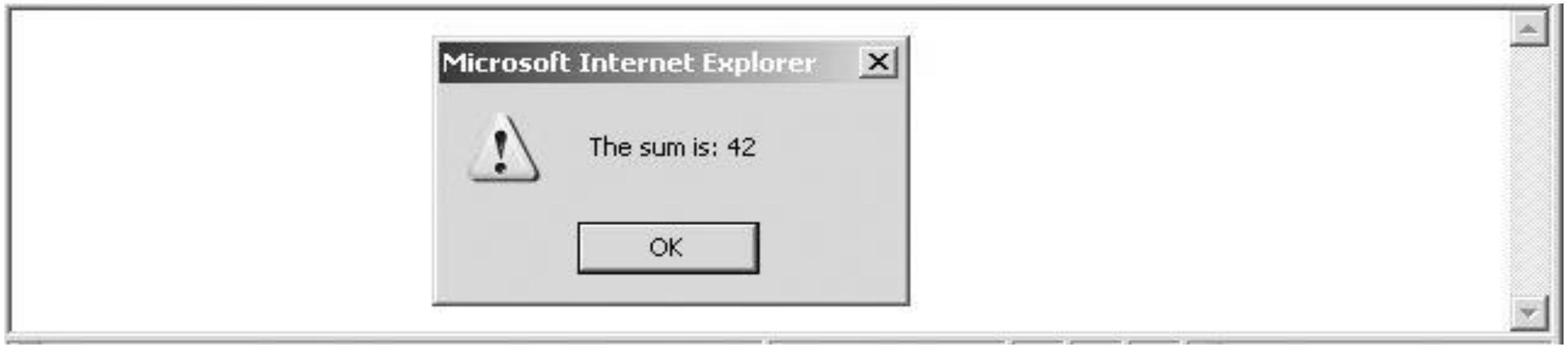
4.5 Screen Output and Keyboard Input

- **Standard output for JavaScript embedded in a browser is the window displaying the page in which the JavaScript is embedded**
- **The write method of the Document object write its parameters to the browser window**
- **The output is interpreted as HTML by the browser**
- **If a line break is needed in the output, interpolate <br/> into the output**

4.5 The alert Method

- **The alert method opens a dialog box with a message**
- **The output of the alert is *not* XHTML, so use new lines rather than <br/>**

```
alert("The sum is:" + sum + "\n");
```



Microsoft Internet Explorer

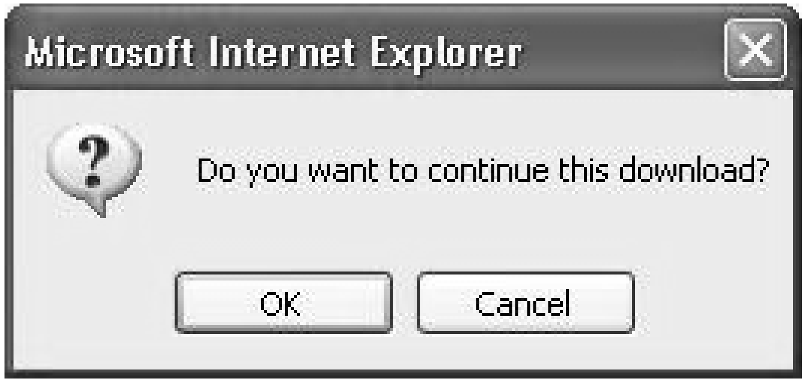
The sum is: 42

OK

4.5 The confirm Method

- The confirm methods displays a message provided as a parameter
  - The confirm dialog has two buttons: OK and Cancel
- If the user presses OK, true is returned by the method
- If the user presses Cancel, false is returned

```
var question =
   confirm("Do you want to continue this download?");
```

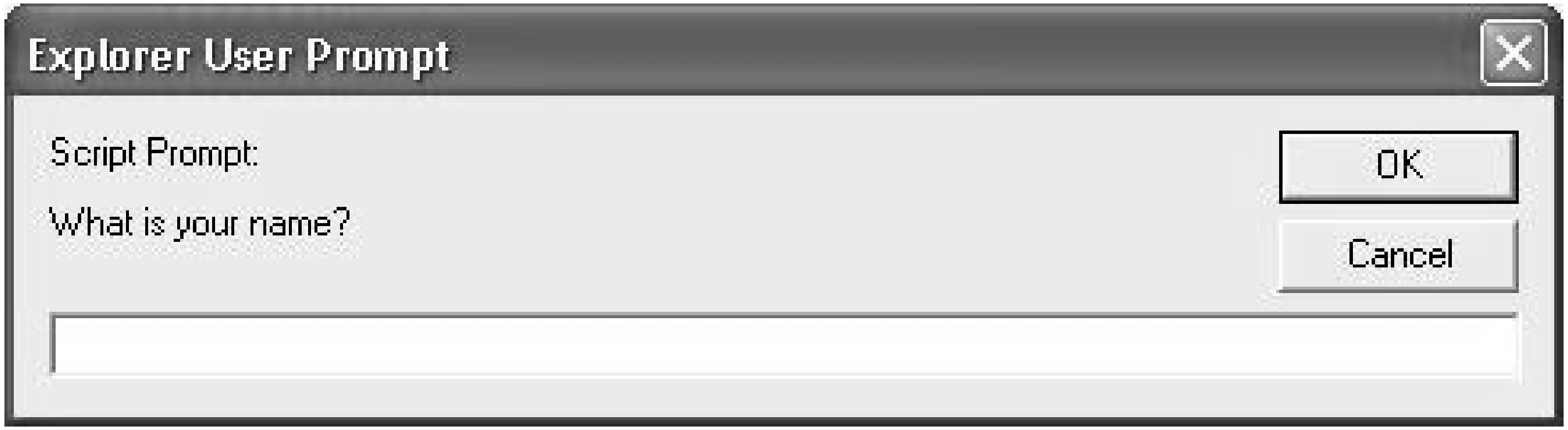


Do you want to continue this download?

4.5 The prompt Method

- **This method displays its string argument in a dialog box**
  - **A second argument provides a default content for the user entry area**
- **The dialog box has an area for the user to enter text**
- **The method returns a String with the text entered by the user**

```
name = prompt("What is your name?", "");
```



4.5 Example of Input and Output

- **roots.html**

4.6 Control Statements

- **A *compound statement* in JavaScript is a sequence of 0 or more statements enclosed in curly braces**
  - **Compound statements can be used as components of control statements allowing multiple statements to be used where, syntactically, a single statement is specified**
- **A *control construct* is a control statement including the statements or compound statements that it contains**

4.6 Control Expressions

- A control expression has a Boolean value
  - An expression with a non-Boolean value used in a control statement will have its value converted to Boolean automatically
- Comparison operators
  - `==   !=   <   <=   >   >=`
  - `===` compares identity of values or objects
  - 3 == ‘3’ is true due to automatic conversion
  - 3 === ‘3’ is false
- Boolean operators
  - `&&   ||   !`
- Warning! A Boolean object evaluates as true
  - Unless the object is null or undefined

4.6 Selection Statements

- **The if-then and if-then-else are similar to that in other programming languages, especially C/C++/Java**

4.6 switch Statement Syntax

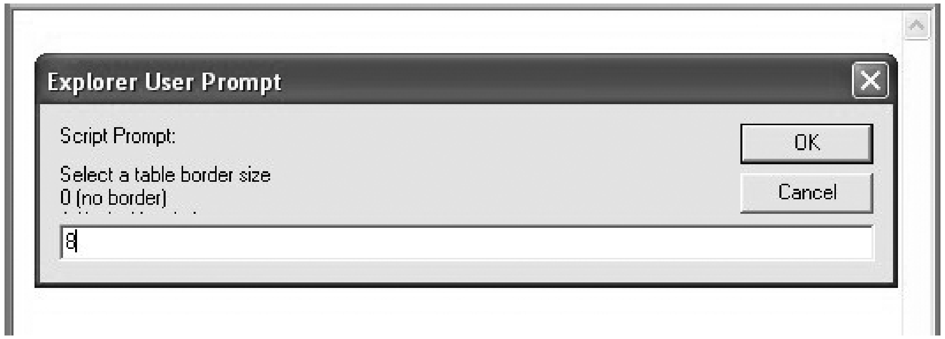
```
switch (expression) {
case value_1:
        // statement(s)
case value_2:
        // statement(s)
...
[default:
        // statement(s)]
}
```

4.6 switch Statement Semantics

- The expression is evaluated
- The value of the expressions is compared to the value in each case in turn
- If no case matches, execution begins at the default case
- Otherwise, execution continues with the statement following the case
- Execution continues until either the end of the switch is encountered or a `break` statement is executed

4.6 Example borders2.js

User Input Prompt

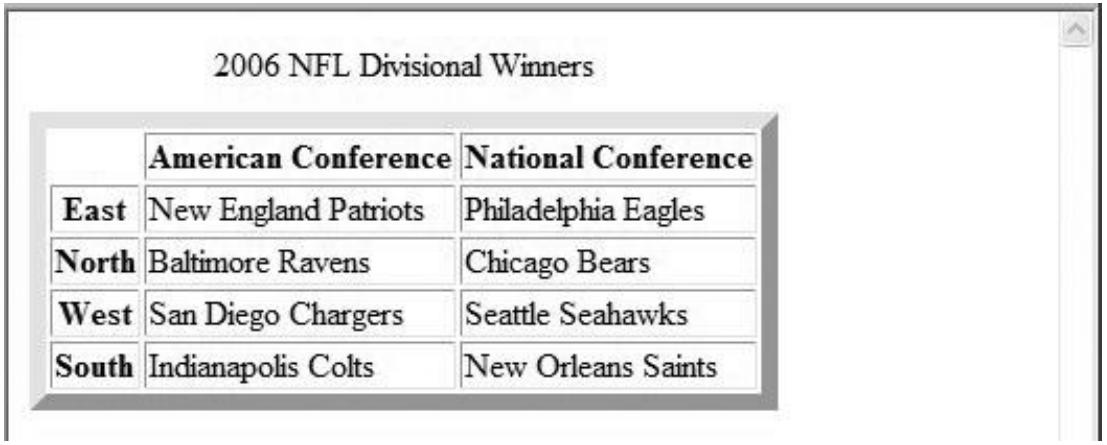


Script Prompt:

Select a table border size
0 (no border)

8

Results



2006 NFL Divisional Winners

	American Conference	National Conference
East	New England Patriots	Philadelphia Eagles
North	Baltimore Ravens	Chicago Bears
West	San Diego Chargers	Seattle Seahawks
South	Indianapolis Colts	New Orleans Saints

4.6 Loop Statements

- **Loop statements in JavaScript are similar to those in C/C++/Java**
- **While**

  `while` (*control expression*)

  statement or compound statement

- **For**

  `for` (*initial expression; control expression; increment expression*)

  statement or compound statement

- **do/while**

  `do` *statement or compound statement*

  `while` (*control expression*)

4.6 date.js Example

- **Uses Date objects to time a calculation**
- **Displays the components of a Date object**
- **Illustrates a for loop**

4.6 `while` Statement Semantics

- **The control expression is evaluated**
- **If the control expression is true, then the statement is executed**
- **These two steps are repeated until the control expression becomes false**
- **At that point the while statement is finished**

4.6 `for` Statement Semantics

- The initial expression is evaluated
- The control expression is evaluated
- If the control expression is true, the statement is executed
- Then the increment expression is evaluated
- The previous three steps are repeated as long as the control expression remains true
- When the control expression becomes false, the statement is finished executing

4.6 `do/while` Statement Semantics

- **The statement is executed**
- **The control expression is evaluated**
- **If the control expression is true, the previous steps are repeated**
- **This continues until the control expression becomes false**
- **At that point, the statement execution is finished**

4.7 Object Creation and Modification

- The new expression is used to create an object
  - This includes a call to a *constructor*
  - The new operator creates a blank object, the constructor creates and initializes all properties of the object
- Properties of an object are accessed using a dot notation: *object*.*property*
- Properties are not variables, so they are not declared
  - An object may be thought of as a Map/Dictionary/Associative-Storage
- The number of properties of an object may vary dynamically in JavaScript

4.7 Dynamic Properties

- **Create my_car and add some properties**

```
// Create an Object object
var my_car = new Object();
// Create and initialize the make property
my_car.make = "Ford";
// Create and initialize model
my_car.model = "Contour SVT";
```

- The delete operator can be used to delete a property from an object
  - `delete my_car.model`

4.7 The for-in Loop

- **Syntax**

  for (*identifier* in *object*)

  statement or compound statement

- The loop lets the identifier take on each property in turn in the object
- Printing the properties in my_car:

```
for (var prop in my_car)
  document.write("Name: ", prop, "; Value: ",
    my_car[prop], "<br />");
```

- Result:

```
Name: make; Value: Ford
Name: model; Value: Contour SVT
```

4.8 Arrays

- Arrays are lists of elements indexed by a numerical value
- Array indexes in JavaScript begin at 0
- Arrays can be modified in size even after they have been created

4.8 `Array` Object Creation

- Arrays can be created using the new Array method
  - new Array with one parameter creates an empty array of the specified number of elements
    - new Array(10)
  - new Array with two or more parameters creates an array with the specified parameters as elements
    - new Array(10, 20)
- Literal arrays can be specified using square brackets to include a list of elements
  - var alist = [1, “ii”, “gamma”, “4”];
- Elements of an array do not have to be of the same type

4.8 Characteristics of `Array` Objects

- **The length of an array is one more than the highest index to which a value has been assigned or the initial size (using Array with one argument), whichever is larger**
- **Assignment to an index greater than or equal to the current length simply increases the length of the array**
- **Only assigned elements of an array occupy space**
  - **Suppose an array were created using new Array(200)**
  - **Suppose only elements 150 through 174 were assigned values**
  - **Only the 25 assigned elements would be allocated storage, the other 175 would not be allocated storage**

4.8 Example insert_names.js

- **This example shows the dynamic nature of arrays in JavaScript**

4.8 `Array` Methods

- join
- reverse
- sort
- concat
- slice

4.8 Dynamic List Operations

- push
  - Add to the end
- pop
  - Remove from the end
- shift
  - Remove from the front
- unshift
  - Add to the front

4.8 Two-dimensional Arrays

- **A two-dimensional array in JavaScript is an array of arrays**
  - **This need not even be rectangular shaped: different rows could have different length**
- **Example nested_arrays.js illustrates two-dimensional arrays**

4.9 Functions

4.9 Function Fundamentals

- **Function definition syntax**
  - **A function definition consist of a header followed by a compound statement**
  - **A function header:**
    - **function *function-name*(*optional-formal-parameters*)**
- **return statements**
  - **A return statement causes a function to cease execution and control to pass to the caller**
  - **A return statement may include a value which is sent back to the caller**
    - **This value may be used in an expression by the caller**
  - **A return statement without a value implicitly returns undefined**
- **Function call syntax**
  - **Function name followed by parentheses and any actual parameters**
  - **Function call may be used as an expression or part of an expression**
- **Functions must defined before use in the page header**

4.9 Functions are Objects

- **Functions are objects in JavaScript**
- **Functions may, therefore, be assigned to variables and to object properties**
  - **Object properties that have function values are methods of the object**
- **Example**

```
function fun() {
  document.write("This surely is fun! <br/>");
}
  ref_fun = fun; // Now, ref_fun refers to the fun object
  fun(); // A call to fun
  ref_fun(); // Also a call to fun
```

4.9 Local Variables

- **“The *scope* of a variable is the range of statements over which it is visible”**
- **A variable not declared using var has global scope, visible throughout the page, even if used inside a function definition**
- **A variable declared with var outside a function definition has global scope**
- **A variable declared with var inside a function definition has local scope, visible only inside the function definition**
  - **If a global variable has the same name, it is hidden inside the function definition**

4.9 Parameters

- **Parameters named in a function header are called *formal parameters***
- **Parameters used in a function call are called *actual parameters***
- **Parameters are passed by value**
  - **For an object parameter, the reference is passed, so the function body can actually change the object**
  - **However, an assignment to the formal parameter will not change the actual parameter**

4.9 Parameter Passing Example

```
function fun1(my_list) {
      var list2 = new Array(1, 3, 5);
      my_list[3] = 14;
      ...
      my_list = list2;
      ...
}
...
var list = new Array(2, 4, 6, 8)
fun1(list);
```

- **The first assignment changes list in the caller**
- **The second assignment has no effect on the list object in the caller**
- **Pass by reference can be simulated by passing an array containing the value**

4.9 Parameter Checking

- **JavaScript checks neither the type nor number of parameters in a function call**
  - **Formal parameters have no type specified**
  - **Extra actual parameters are ignored (however, see below)**
  - **If there are fewer actual parameters than formal parameters, the extra formal parameters remain undefined**
- **This is typical of scripting languages**
- **A property array named arguments holds all of the actual parameters, whether or not there are more of them than there are formal parameters**
  - **Example params.js illustrates this**

4.9 The `sort` Method, Revisited

- A parameter can be passed to the sort method to specify how to sort elements in an array
  - The parameter is a function that takes two parameters
  - The function returns a negative value to indicate the first parameter should come before the second
  - The function returns a positive value to indicate the first parameter should come after the second
  - The function returns 0 to indicate the first parameter and the second parameter are equivalent as far as the ordering is concerned
- Example median.js illustrates the sort method

4.11 Constructors

- Constructors are functions that create an initialize properties for new objects
- A constructor uses the keyword this in the body to reference the object being initialized
- Object methods are properties that refer to functions
  - A function to be used as a method may use the keyword this to refer to the object for which it is acting
- Example car_constructor.html

4.12 Using Regular Expressions

- Regular expressions are used to specify patterns in strings
- JavaScript provides two methods to use regular expressions in pattern matching
  - String methods
  - RegExp objects (not covered in the text)
- A literal regular expression pattern is indicated by enclosing the pattern in slashes
- The search method returns the position of a match, if found, or -1 if no match was found

4.12 Example Using search

```
var str = "Rabbits are furry";
var position = str.search(/bits/);
if (position > 0)
      document.write("'bits' appears in position",
            position, "<br />");
else
      document.write(
            "'bits' does not appear in str <br />");
```

- **This uses a pattern that matches the string ‘bits’**
- **The output of this code is as follows:**

  'bits' appears in position 3

4.12 Characters and Character-Classes

- *Metacharacters* have special meaning in regular expressions
  - `\ | ( ) [ ] { } ^ $ * + ? .`
  - These characters may be used literally by escaping them with \
- Other characters represent themselves
- A period matches any single character
  - /f.r/ matches for and far and fir but not fr
- A character class matches one of a specified set of characters
  - [*character set*]
  - List characters individually: [abcdef]
  - Give a range of characters: [a-z]
  - Beware of [A-z]
  - ^ at the beginning negates the class

4.12 Predefined character classes

Name	Equivalent Pattern	Matches
\d	[0-9]	A digit
\D	[^0-9]	Not a digit
\w	[A-Za-z_0-9]	A word character (alphanumeric)
\W	[^A-Za-z_0-9]	Not a word character
\s	[\r\t\n\f]	A whitespace character
\S	[^ \r\t\n\f]	Not a whitespace character

4.12 Repeated Matches

- **A pattern can be repeated a fixed number of times by following it with a pair of curly braces enclosing a count**
- **A pattern can be repeated by following it with one of the following special characters**
  - **`*` indicates zero or more repetitions of the previous pattern**
  - **+ indicates one or more of the previous pattern**
  - **? indicates zero or one of the previous pattern**
- **Examples**
  - `/\(\d{3}\)\d{3}-\d{4}/` **might represent a telephone number**
  - `/[$_a-zA-Z][$_a-zA-Z0-9]*/` **matches identifiers**

4.12 Anchors

- **Anchors in regular expressions match positions rather than characters**
  - **Anchors are 0 width and may not take multiplicity modifiers**
- **Anchoring to the end of a string**
  - **^ at the beginning of a pattern matches the beginning of a string**
  - **$ at the end of a pattern matches the end of a string**
    - **The $ in /a$b/ matches a $ character**
- **Anchoring at a word boundary**
  - **\b matches the position between a word character and a non-word character or the beginning or the end of a string**
  - **/\bthe\b/ will match ‘the’ but not ‘theatre’ and will also match ‘the’ in the string ‘one of the best’**

4.12 Pattern Modifiers

- Pattern modifiers are specified by characters that follow the closing / of a pattern
- Modifiers modify the way a pattern is interpreted or used
- The x modifier causes whitespace in the pattern to be ignored
  - This allows better formatting of the pattern
  - \s still retains its meaning
- The g modifier is explained in the following

4.12 Other Pattern Matching Methods

- The replace method takes a pattern parameter and a string parameter
  - The method replaces a match of the pattern in the target string with the second parameter
  - A g modifier on the pattern causes multiple replacements
- Parentheses can be used in patterns to mark sub-patterns
  - The pattern matching machinery will remember the parts of a matched string that correspond to sub-patterns
- The match method takes one pattern parameter
  - Without a g modifier, the return is an array of the match and parameterized sub-matches
  - With a g modifier, the return is an array of all matches
- The split method splits the object string using the pattern to specify the split points

4.13 An Example

- **forms_check.js**
- **Using javascript to check the validity of input data**
- **Note, a server program may need to check the data sent to it since the validation can be bypassed in a number of ways**

4.14 Errors in Scripts

- JavaScript errors are detected by the browser
- Different browsers report this differently
  - Firefox uses a special console
- Support for debugging is provided
  - In IE 7, the debugger is part of the browser
  - For Firefox 2, plug-ins are available
    - These include Venkman and Firebug