

# **ECMAScript LANGUAGE SPECIFICATION**

**ECMA COMMITTEE #39**

**VERSION 0.18**

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<b>1 SCOPE</b> .....	<b>1</b>
<b>2 CONFORMANCE</b> .....	<b>2</b>
<b>3 REFERENCES</b> .....	<b>3</b>
<b>4 OVERVIEW</b> .....	<b>4</b>
4.1 WEB SCRIPTING.....	4
4.2 LANGUAGE OVERVIEW.....	4
4.2.1 <i>Objects</i> .....	5
4.3 DEFINITIONS.....	6
4.3.1 <i>Type</i> .....	6
4.3.2 <i>Primitive Value</i> .....	6
4.3.3 <i>Object</i> .....	6
4.3.4 <i>Constructor</i> .....	6
4.3.5 <i>Prototype</i> .....	7
4.3.6 <i>Native Object</i> .....	7
4.3.7 <i>Built-In Object</i> .....	7
4.3.8 <i>Host Object</i> .....	7
4.3.9 <i>Undefined</i> .....	7
4.3.10 <i>Undefined Type</i> .....	7
4.3.11 <i>Null</i> .....	7
4.3.12 <i>Null Type</i> .....	7
4.3.13 <i>Boolean Value</i> .....	7
4.3.14 <i>Boolean Type</i> .....	7
4.3.15 <i>Boolean Object</i> .....	7
4.3.16 <i>String Value</i> .....	8
4.3.17 <i>String Type</i> .....	8
4.3.18 <i>String Object</i> .....	8
4.3.19 <i>Number Value</i> .....	8
4.3.20 <i>Number Type</i> .....	8
4.3.21 <i>Number Object</i> .....	8
4.3.22 <i>Infinity</i> .....	8
4.3.23 <i>NaN</i> .....	8
<b>5 NOTATIONAL CONVENTIONS</b> .....	<b>9</b>
5.1 SYNTACTIC AND LEXICAL GRAMMARS.....	9
5.1.1 <i>Context-Free Grammars</i> .....	9
5.1.2 <i>The Lexical Grammar</i> .....	9
5.1.3 <i>The Numeric String Grammar</i> .....	9
5.1.4 <i>The Syntactic Grammar</i> .....	9
5.1.5 <i>Grammar Notation</i> .....	10
5.2 ALGORITHM CONVENTIONS.....	12
<b>6 SOURCE TEXT</b> .....	<b>13</b>
<b>7 LEXICAL CONVENTIONS</b> .....	<b>14</b>
7.1 WHITE SPACE.....	14
7.2 LINE TERMINATORS.....	14
7.3 COMMENTS.....	15
7.4 TOKENS.....	15
7.4.1 <i>Reserved Words</i> .....	15
7.4.2 <i>Keywords</i> .....	16
7.4.3 <i>Future Reserved Words</i> .....	16
7.5 IDENTIFIERS.....	16
7.6 PUNCTUATORS.....	17
7.7 LITERALS.....	17

7.7.1 <i>Null Literals</i> .....	17
7.7.2 <i>Boolean Literals</i> .....	17
7.7.3 <i>Numeric Literals</i> .....	17
7.7.4 <i>String Literals</i> .....	19
7.8 AUTOMATICSEMICOLONINSERTION.....	22
<b>8 TYPES.....</b>	<b>24</b>
8.1 THE UNDEFINEDTYPE.....	24
8.2 THE NULL TYPE.....	24
8.3 THE BOOLEAN TYPE.....	24
8.4 THE STRING TYPE.....	24
8.5 THE NUMBER TYPE.....	24
8.6 THE OBJECT TYPE.....	25
8.6.1 <i>Property Attributes</i> .....	25
8.6.2 <i>Internal Properties and Methods</i> .....	26
8.6.2.1 <i>[[Get]](P)</i> .....	26
8.6.2.2 <i>[[Put]](P, V)</i> .....	27
8.6.2.3 <i>[[CanPut]](P)</i> .....	27
8.6.2.4 <i>[[HasProperty]](P)</i> .....	27
8.6.2.5 <i>[[DefaultValue]](hint)</i> .....	27
8.7 THE REFERENCE TYPE.....	28
8.7.1 <i>GetBase(V)</i> .....	28
8.7.2 <i>GetPropertyname(V)</i> .....	28
8.7.3 <i>GetValue(V)</i> .....	28
8.7.4 <i>PutValue(V, W)</i> .....	28
8.8 THE LIST TYPE.....	28
8.9 THE COMPLETIONTYPE.....	29
<b>9 TYPE CONVERSION.....</b>	<b>30</b>
9.1 TOPRIMITIVE.....	30
9.2 TOBOOLEAN.....	30
9.3 TONUMBER.....	31
9.3.1 <i>ToNumber Applied to the String Type</i> .....	31
9.4 TOINTEGER.....	33
9.5 TOINT32: (SIGNED32 BIT INTEGER).....	34
9.6 TOUINT32: (UNSIGNED32 BIT INTEGER).....	34
9.7 TOUINT16: (UNSIGNED16 BIT INTEGER).....	34
9.8 TOSTRING.....	35
9.8.1 <i>ToString Applied to the Number Type</i> .....	35
9.9 TOOBJECT.....	36
<b>10 EXECUTION CONTEXTS.....</b>	<b>37</b>
10.1 DEFINITIONS.....	37
10.1.1 <i>Function Objects</i> .....	37
10.1.2 <i>Types of Executable Code</i> .....	37
10.1.3 <i>Variable Instantiation</i> .....	38
10.1.4 <i>Scope Chain and Identifier Resolution</i> .....	38
10.1.5 <i>Global Object</i> .....	39
10.1.6 <i>Activation Object</i> .....	39
10.1.7 <i>This</i> .....	39
10.1.8 <i>Arguments Object</i> .....	39
10.2 ENTERING AN EXECUTIONCONTEXT.....	40
10.2.1 <i>Global Code</i> .....	40
10.2.2 <i>EvalCode</i> .....	40
10.2.3 <i>Function and Anonymous Code</i> .....	40
10.2.4 <i>Host Code</i> .....	40
<b>11 EXPRESSIONS.....</b>	<b>41</b>
11.1 PRIMARY EXPRESSIONS.....	41

11.1.1	The <i>this</i> Keyword.....	41
11.1.2	Identifier Reference.....	41
11.1.3	Literal Reference.....	41
11.1.4	The Grouping Operator.....	41
11.2	LEFT-HAND-SIDE EXPRESSIONS.....	41
11.2.1	Property Accessors.....	42
11.2.2	The <i>new</i> Operator.....	42
11.2.3	Function Calls.....	43
11.2.4	Argument Lists.....	43
11.3	POSTFIX EXPRESSIONS.....	43
11.3.1	Postfix Increment Operator.....	44
11.3.2	Postfix Decrement Operator.....	44
11.4	UNARY OPERATORS.....	44
11.4.1	The <i>delete</i> Operator.....	44
11.4.2	The <i>void</i> Operator.....	45
11.4.3	The <i>typeof</i> Operator.....	45
11.4.4	Prefix Increment Operator.....	45
11.4.5	Prefix Decrement Operator.....	45
11.4.6	Unary + Operator.....	45
11.4.7	Unary - Operator.....	46
11.4.8	The Bitwise NOT Operator ( <i>~</i> ).....	46
11.4.9	Logical NOT Operator ( <i>!</i> ).....	46
11.5	MULTIPLICATIVE OPERATORS.....	46
11.5.1	Applying the * Operator.....	47
11.5.2	Applying the / Operator.....	47
11.5.3	Applying the % Operator.....	47
11.6	ADDITIVE OPERATORS.....	48
11.6.1	The Addition Operator ( + ).....	48
11.6.2	The Subtraction Operator ( - ).....	49
11.6.3	Applying the Additive Operators ( +, - ) to Numbers.....	49
11.7	BITWISE SHIFT OPERATORS.....	49
11.7.1	The Left Shift Operator ( << ).....	49
11.7.2	The Signed Right Shift Operator ( >> ).....	50
11.7.3	The Unsigned Right Shift Operator ( >>> ).....	50
11.8	RELATIONAL OPERATORS.....	50
11.9	EQUALITY OPERATORS.....	52
11.10	BINARY BITWISE OPERATORS.....	53
11.11	BINARY LOGICAL OPERATORS.....	53
11.12	CONDITIONAL OPERATOR ( <i>?:</i> ).....	54
11.13	ASSIGNMENT OPERATORS.....	54
11.13.1	Simple Assignment ( = ).....	54
11.13.2	Compound Assignment ( <i>op=</i> ).....	55
11.14	COMMA OPERATOR ( , ).....	55
<b>12</b>	<b>STATEMENTS.....</b>	<b>56</b>
12.1	VARIABLE STATEMENT.....	57
12.2	EMPTY STATEMENT.....	57
12.3	EXPRESSION STATEMENT.....	58
12.4	THE <i>if</i> STATEMENT.....	58
12.5	ITERATION STATEMENTS.....	58
12.5.1	The <i>while</i> Statement.....	58
12.5.2	The <i>for</i> Statement.....	59
12.5.3	The <i>for..in</i> Statement.....	60
12.6	THE <i>continue</i> STATEMENT.....	60
12.7	THE <i>break</i> STATEMENT.....	61
12.8	THE <i>return</i> STATEMENT.....	61
12.9	THE <i>with</i> STATEMENT.....	61

<b>13 FUNCTION DEFINITION.....</b>	<b>62</b>
<b>14 PROGRAM.....</b>	<b>63</b>
<b>15 NATIVE ECMAScript OBJECTS.....</b>	<b>64</b>
15.1 THE GLOBAL OBJECT.....	64
15.1.1 Value Properties of the Global Object.....	64
15.1.1.1 NaN.....	64
15.1.1.2 Infinity.....	65
15.1.2 Function Properties of the Global Object.....	65
15.1.2.1 eval(x).....	65
15.1.2.2 parseInt(string, radix).....	65
15.1.2.3 parseFloat(string).....	66
15.1.2.4 escape(string).....	66
15.1.2.5 unescape(string).....	66
15.1.2.6 isNaN(number).....	67
15.1.2.7 isFinite(number).....	67
15.2 OBJECT OBJECTS.....	67
15.2.1 The Object Constructor Called as a Function.....	67
15.2.1.1 Object(value).....	67
15.2.1.2 Object().....	67
15.2.2 The Object Constructor.....	67
15.2.2.1 new Object(value).....	67
15.2.2.2 new Object().....	68
15.2.3 Properties of the Object Constructor.....	68
15.2.3.1 Object.prototype.....	68
15.2.4 Properties of the Object Prototype Object.....	68
15.2.4.1 Object.prototype.constructor.....	68
15.2.4.2 Object.prototype.toString().....	69
15.2.4.3 Object.prototype.valueOf().....	69
15.2.5 Properties of Object Instances.....	69
15.3 FUNCTION OBJECTS.....	69
15.3.1 The Function Constructor Called as a Function.....	69
15.3.1.1 Function(p1, p2, . . . , pn, body).....	69
15.3.2 The Function Constructor.....	69
15.3.2.1 Function(p1, p2, . . . , pn, body).....	69
15.3.3 Properties of the Function Constructor.....	70
15.3.3.1 Function.prototype.....	70
15.3.3.2 Function.length.....	70
15.3.4 Properties of the Function Prototype Object.....	71
15.3.4.1 Function.prototype.constructor.....	71
15.3.4.2 Function.prototype.toString().....	71
15.3.5 Properties of Function Instances.....	71
15.3.5.1 length.....	71
15.3.5.2 prototype.....	71
15.3.5.3 arguments.....	71
15.4 ARRAY OBJECTS.....	71
15.4.1 The Array Constructor.....	72
15.4.1.1 new Array(item0, item1, . . . ).....	72
15.4.1.2 new Array(len).....	72
15.4.1.3 new Array().....	72
15.4.2 Properties of the Array Constructor.....	72
15.4.2.1 Array.prototype.....	72
15.4.2.2 Array.length.....	72
15.4.3 Properties of the Array Prototype Object.....	72
15.4.3.1 Array.prototype.constructor.....	72
15.4.3.2 Array.prototype.toString().....	72
15.4.3.3 Array.prototype.valueOf().....	73
15.4.3.4 Array.prototype.join(separator).....	73
15.4.3.5 Array.prototype.reverse().....	73
15.4.3.6 Array.prototype.sort(comparefn).....	73
15.4.4 Properties of Array Instances.....	74
15.4.4.1 [[Put]](P, V).....	74

15.4.4.2	length.....	75
15.5	STRING OBJECTS .....	75
15.5.1	<i>The String Constructor Called as a Function</i> .....	75
15.5.1.1	String(value).....	75
15.5.1.2	String() .....	75
15.5.2	<i>The String Constructor</i> .....	75
15.5.2.1	new String(value).....	75
15.5.2.2	new String().....	75
15.5.3	<i>Properties of the String Constructor</i> .....	75
15.5.3.1	String.prototype.....	75
15.5.3.2	String.fromCharCode(char0, char1, . . .).....	76
15.5.4	<i>Properties of the String Prototype Object</i> .....	76
15.5.4.1	String.prototype.constructor.....	76
15.5.4.2	String.prototype.toString().....	76
15.5.4.3	String.prototype.valueOf().....	76
15.5.4.4	String.prototype.charAt(pos).....	76
15.5.4.5	String.prototype.charCodeAt(pos).....	76
15.5.4.6	String.prototype.indexOf(searchString, position).....	77
15.5.4.7	String.prototype.lastIndexOf(searchString, position).....	77
15.5.4.8	String.prototype.split(separator).....	77
15.5.4.9	String.prototype.substring(start).....	78
15.5.4.10	String.prototype.substring(start, end).....	78
15.5.4.11	String.prototype.toLowerCase.....	79
15.5.4.12	String.prototype.toUpperCase.....	79
15.5.5	<i>Properties of String Instances</i> .....	79
15.5.5.1	length.....	79
15.6	BOOLEAN OBJECTS.....	79
15.6.1	<i>The Boolean Constructor Called as a Function</i> .....	79
15.6.1.1	Boolean(value).....	79
15.6.1.2	Boolean().....	80
15.6.2	<i>The Boolean Constructor</i> .....	80
15.6.2.1	new Boolean(value).....	80
15.6.2.2	new Boolean().....	80
15.6.3	<i>Properties of the Boolean Constructor</i> .....	80
15.6.3.1	Boolean.prototype .....	80
15.6.4	<i>Properties of the Boolean Prototype Object</i> .....	80
15.6.4.1	Boolean.prototype.constructor .....	80
15.6.4.2	Boolean.prototype.toString().....	80
15.6.4.3	Boolean.prototype.valueOf().....	80
15.6.5	<i>Properties of Boolean Instances</i> .....	80
15.7	NUMBER OBJECTS.....	81
15.7.1	<i>The Number Constructor Called as a Function</i> .....	81
15.7.1.1	Number(value).....	81
15.7.1.2	Number().....	81
15.7.2	<i>The Number Constructor</i> .....	81
15.7.2.1	new Number(value).....	81
15.7.2.2	new Number().....	81
15.7.3	<i>Properties of the Number Constructor</i> .....	81
15.7.3.1	Number.prototype.....	81
15.7.3.2	Number.MAX_VALUE.....	81
15.7.3.3	Number.MIN_VALUE.....	81
15.7.3.4	Number.NaN.....	81
15.7.3.5	Number.NEGATIVE_INFINITY.....	81
15.7.3.6	Number.POSITIVE_INFINITY.....	82
15.7.4	<i>Properties of the Number Prototype Object</i> .....	82
15.7.4.1	Number.prototype.constructor.....	82
15.7.4.2	Number.prototype.toString().....	82
15.7.4.3	Number.prototype.valueOf().....	82
15.7.5	<i>Properties of Number Instances</i> .....	82
15.8	THE MATH OBJECT .....	82
15.8.1	<i>Value Properties of the Math Object</i> .....	82
15.8.1.1	E .....	82
15.8.1.2	LN10 .....	82

15.8.1.3 LN2 .....	83
15.8.1.4 LOG2E .....	83
15.8.1.5 LOG10E .....	83
15.8.1.6 PI .....	83
15.8.1.7 SQRT1_2 .....	83
15.8.1.8 SQRT2 .....	83
<i>15.8.2 Function Properties of the Math Object</i> .....	<i>83</i>
15.8.2.1 abs(x) .....	83
15.8.2.2 acos(x) .....	84
15.8.2.3 asin(x) .....	84
15.8.2.4 atan(x) .....	84
15.8.2.5 atan2(y, x) .....	84
15.8.2.6 ceil(x) .....	85
15.8.2.7 cos(x) .....	85
15.8.2.8 exp(x) .....	85
15.8.2.9 floor(x) .....	85
15.8.2.10 log(x) .....	85
15.8.2.11 max(x, y) .....	86
15.8.2.12 min(x, y) .....	86
15.8.2.13 pow(x, y) .....	86
15.8.2.14 random() .....	87
15.8.2.15 round(x) .....	87
15.8.2.16 sin(x) .....	87
15.8.2.17 sqrt(x) .....	87
15.8.2.18 tan(x) .....	87
<b>15.9 DATE OBJECTS</b> .....	<b>87</b>
<i>15.9.1 Overview of Date Objects</i> .....	<i>87</i>
15.9.1.1 Time Range .....	88
15.9.1.2 Day Number and Time within Day .....	88
15.9.1.3 Year Number .....	88
15.9.1.4 Month Number .....	88
15.9.1.5 Date Number .....	89
15.9.1.6 Week Day .....	89
15.9.1.7 Local Time Zone Adjustment .....	89
15.9.1.8 Daylight Saving Time Adjustment .....	90
15.9.1.9 Local Time .....	90
15.9.1.10 Hours, Minutes, Second, and Milliseconds .....	90
15.9.1.11 MakeTime(hour, min, sec, ms) .....	91
15.9.1.12 MakeDay(year, month, date) .....	91
15.9.1.13 MakeDate(day, time) .....	91
15.9.1.14 TimeClip(time) .....	91
<i>15.9.2 The Date Constructor</i> .....	<i>91</i>
15.9.2.1 new Date(year, month, date, hours, minutes, seconds, ms) .....	91
15.9.2.2 new Date(year, month, date, hours, minutes, seconds) .....	92
15.9.2.3 new Date(year, month, date, hours, minutes) .....	92
15.9.2.4 new Date(year, month, date, hours) .....	92
15.9.2.5 new Date(year, month, day) .....	93
15.9.2.6 new Date(year, month) .....	93
15.9.2.7 new Date(value) .....	93
15.9.2.8 new Date() .....	93
<i>15.9.3 Properties of the Date Constructor</i> .....	<i>93</i>
15.9.3.1 Date.prototype .....	93
15.9.3.2 Date.parse(string) .....	93
15.9.3.3 Date.UTC(year, month, date, hours, minutes, seconds, ms) .....	94
15.9.3.4 Date.UTC(year, month, date, hours, minutes, seconds) .....	94
15.9.3.5 Date.UTC(year, month, date, hours, minutes) .....	94
15.9.3.6 Date.UTC(year, month, date, hours) .....	94
15.9.3.7 Date.UTC(year, month, date) .....	95
15.9.3.8 Date.UTC(year, month) .....	95
15.9.3.9 Date.UTC(year) .....	95
15.9.3.10 Date.UTC() .....	95
<i>15.9.4 Properties of the Date Prototype Object</i> .....	<i>95</i>
15.9.4.1 Date.prototype.constructor .....	95
15.9.4.2 Date.prototype.toString() .....	95
15.9.4.3 Date.prototype.valueOf() .....	95

15.9.4.4	Date.prototype.getTime()	96
15.9.4.5	Date.prototype.getYear()	96
15.9.4.6	Date.prototype.getFullYear()	96
15.9.4.7	Date.prototype.getUTCFullYear()	96
15.9.4.8	Date.prototype.getMonth()	96
15.9.4.9	Date.prototype.getUTCMonth()	96
15.9.4.10	Date.prototype.getDate()	96
15.9.4.11	Date.prototype.getUTCDate()	96
15.9.4.12	Date.prototype.getDay()	96
15.9.4.13	Date.prototype.getUTCDay()	96
15.9.4.14	Date.prototype.getHours()	97
15.9.4.15	Date.prototype.getUTCHours()	97
15.9.4.16	Date.prototype.getMinutes()	97
15.9.4.17	Date.prototype.getUTCMinutes()	97
15.9.4.18	Date.prototype.getSeconds()	97
15.9.4.19	Date.prototype.getUTCSeconds()	97
15.9.4.20	Date.prototype.getMilliseconds()	97
15.9.4.21	Date.prototype.getUTCMilliseconds()	97
15.9.4.22	Date.prototype.getTimezoneOffset()	97
15.9.4.23	Date.prototype.setTime(time)	97
15.9.4.24	Date.prototype.setMilliseconds(ms)	98
15.9.4.25	Date.prototype.setUTCMilliseconds(ms)	98
15.9.4.26	Date.prototype.setSeconds(sec [ , ms ] )	98
15.9.4.27	Date.prototype.setUTCSeconds(sec [ , ms ] )	98
15.9.4.28	Date.prototype.setMinutes(min [ , sec [ , ms ] ] )	98
15.9.4.29	Date.prototype.setUTCMinutes(min [ , sec [ , ms ] ] )	98
15.9.4.30	Date.prototype.setHours(hour [ , min [ , sec [ , ms ] ] ] )	99
15.9.4.31	Date.prototype.setUTCHours(hour [ , min [ , sec [ , ms ] ] ] )	99
15.9.4.32	Date.prototype.setDate(date)	99
15.9.4.33	Date.prototype.setUTCDate(date)	99
15.9.4.34	Date.prototype.setMonth(mon [ , date ] )	100
15.9.4.35	Date.prototype.setUTCMonth(mon [ , date ] )	100
15.9.4.36	Date.prototype.setFullYear(year [ , mon [ , date ] ] )	100
15.9.4.37	Date.prototype.setUTCFullYear(year [ , mon [ , date ] ] )	100
15.9.4.38	Date.prototype.setYear(year)	100
15.9.4.39	Date.prototype.toLocaleString()	101
15.9.4.40	Date.prototype.toUTCString()	101
15.9.4.41	Date.prototype.toGMTString()	101
15.9.5	<i>Properties of Date Instances</i>	101
<b>16</b>	<b>ERRORS</b>	<b>102</b>



# 1 SCOPE

(To be supplied.)

## 2 CONFORMANCE

A conforming implementation of ECMAScript must provide and support all the types, values, objects, properties, functions, and program syntax described in this specification.

A conforming implementation of ECMAScript is permitted to provide additional types, values, objects, properties, and functions beyond those described in this specification. In particular, a conforming implementation of ECMAScript is permitted to provide properties not described in this specification, and values for those properties, for objects that are described in this specification.

A conforming implementation of ECMAScript is permitted to support program syntax not described in this specification. In particular, a conforming implementation of ECMAScript is permitted to support program syntax that makes use of the “future reserved words” listed in section 4.3 of this specification.

### 3 REFERENCES

RFC 1738 for % escape sequences

Unicode or 10646 specification

IEEE 754 standard

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David Ungar and Randall B. Smith. *Self: The Power of Simplicity*. OOPSLA '87 Conference Proceedings, pp. 227-241, Orlando, FL, October, 1987.

## 4 OVERVIEW

ECMAScript is an object-oriented programming language for performing computations and manipulating computational objects within a host environment. ECMAScript as defined here is not intended to be computationally self-sufficient; indeed, there are no provisions in this specification for input of external data or output of computed results. Instead, it is expected that the computational environment of an ECMAScript program will provide not only the objects and other facilities described in this specification but also certain environment-specific *host* objects, whose description and behavior are beyond the scope of this specification except to indicate that they may provide certain properties that can be accessed and certain functions that can be called from an ECMAScript program.

A *scripting language* is a programming language that is used to manipulate, customize, and automate the facilities of an existing system. In such systems, useful functionality is already available through a user interface, and the scripting language is a mechanism for exposing that functionality to program control. In this way, the existing system is said to provide a host environment of objects and facilities which completes the capabilities of the scripting language. A scripting language is intended for use by both professional and non-professional programmers, and therefore there may be a number of informalities and built into the language.

ECMAScript was originally designed to be a *Web scripting language*, providing a mechanism to enliven Web pages in browsers and to perform server computation as part of a Web-based client-server architecture. ECMAScript can provide core scripting capabilities for a variety of host environments, and therefore the core scripting language is specified in this document apart from any particular host environment.

### 4.1 WEB SCRIPTING

A web browser provides an ECMAScript host environment for client-side computation including, for instance, objects that represent windows, menus, pop-ups, dialog boxes, text areas, anchors, frames, history, cookies, and input/output. Further, the host environment provides a means to attach scripting code to events such as change of focus, page and image loading, unloading, error, and abort, selection, form submission, and mouse actions. Scripting code appears within the HTML and the displayed page is a combination of user interface elements and fixed and computed text and images. The scripting code is reactive to user interaction and there is no need for a main program.

A web server provides a different host environment for server-side computation including objects representing requests, clients, and files, and mechanisms to lock and share data. By using browser-side and server side scripting together it is possible to distribute computation between the client and server while providing a customized user interface for a Web-based application.

Each Web browser and server that supports ECMAScript supplies its own host environment, completing the ECMAScript execution environment.

### 4.2 LANGUAGE OVERVIEW

The following is an informal overview of ECMAScript—not all parts of the language are described. This overview is not part of the standard proper.

ECMAScript is object-based: basic language and host facilities are provided by objects, and an ECMAScript program is a cluster of communicating objects. An ECMAScript *object* is an unordered collection of *properties* each with 0 or more *attributes* which determine how each property can be used—for example, when the *ReadOnly* attribute for a property is set to true, any attempt by executed ECMAScript code to change the value of the property has no effect. Properties are containers that hold other objects, *primitive values*, or *methods*. A primitive value is a member of one of the following

built-in types: **Undefined**, **Null**, **Boolean**, **Number**, and **String**; an object is a member of the remaining built-in type **Object**; and a method is a function associated with an object via a property.

ECMAScript defines a collection of *built-in objects* which round out the definition of ECMAScript entities. These built-in objects include the **Global** object, the **Object** object, the **Function** object, the **Array** object, the **String** object, the **Boolean** object, the **Number** object, the **Math** object, and the **Date** object.

ECMAScript also defines a set of built-in *operators* which may not be, strictly speaking, functions or methods. ECMAScript operators include various unary operations, multiplicative operators, additive operators, bitwise shift operators, relational operators, equality operators, binary bitwise operators, binary logical operators, assignment operators, and the comma operator.

ECMAScript syntax intentionally resembles Java syntax. ECMAScript syntax is relaxed to enable it to serve as an easy-to-use scripting language. For example, a variable is not required to have its type declared nor are types associated with properties, and undefined functions are not required to have their declarations appear textually before calls to them

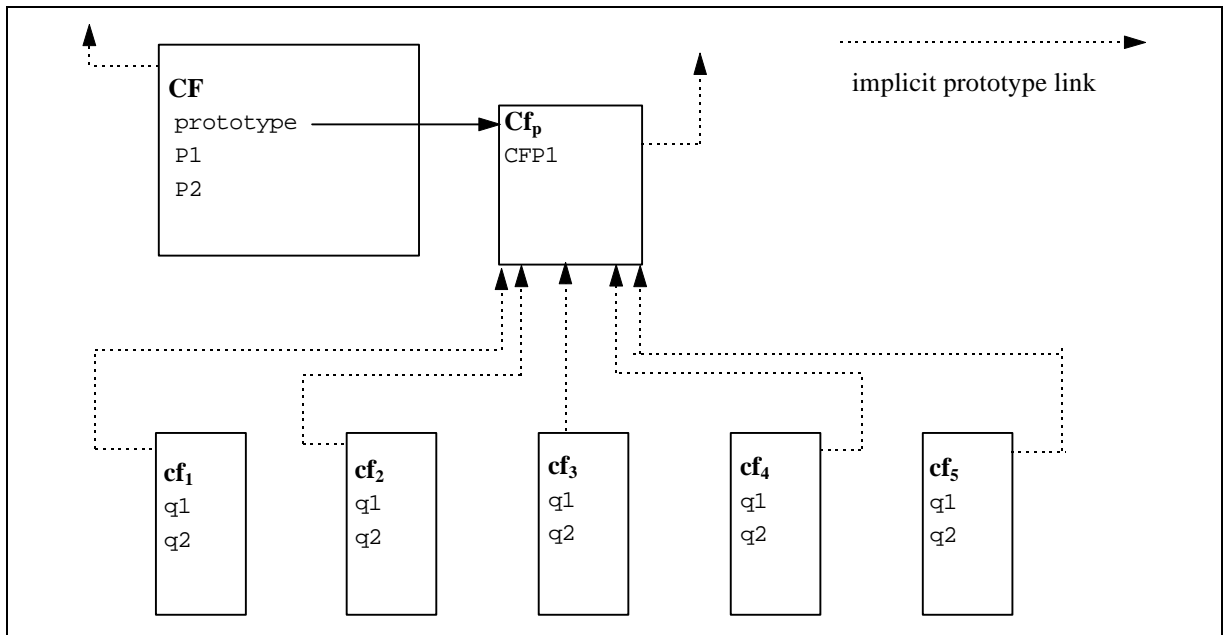
### 4.2.1 Objects

ECMAScript does not contain proper classes such as those in C++, Smalltalk, or Java, but rather, supports *constructors* which create objects by executing code that allocates storage for the objects and initializes all or part of them by assigning initial values to their properties. All functions including constructors are objects, but not all objects are constructors. Each constructor has **Prototype** property which is used to implement *prototype-based inheritance* and *shared properties*. Objects are created by using constructors in **new** expressions, for example, `new String("A String")` creates a new string object. Invoking a constructor without using **new** has consequences that depend on the constructor. For example, `String("A String")` produces a primitive string, not an object.

ECMAScript supports *prototype-based inheritance*. Every constructor has an associated prototype, and every object created by that constructor has an implicit reference to the prototype (called the *object's prototype*) associated with its constructor. Furthermore, a prototype may have a non-null implicit reference to its prototype, and so on; this is called the *prototype chain*. When a reference is made to a property in an object, that reference is to the property of that name in the first object in the prototype chain that contains a property of that name. In other words, first the object mentioned directly is examined for such a property; if that object contains the named property, that is the property to which the reference refers; if that object does not contain the named property, the prototype for that object is examined next; and so on.

In a class-based object-oriented language, in general, state is carried by instances, methods are carried by classes, and inheritance is only of structure and behavior. In ECMAScript, the state and methods are carried by objects, and structure, behavior, and state are all inherited.

All objects that do not directly contain a particular property that their prototype contains share that property and its value. The following diagram may illustrate this discussion:



**CF** is a constructor (and also an object). Five objects have been created by using new expressions **cf<sub>1</sub>**, **cf<sub>2</sub>**, **cf<sub>3</sub>**, **cf<sub>4</sub>**, and **cf<sub>5</sub>**. Each of these objects contains properties named **q<sub>1</sub>** and **q<sub>2</sub>**. The dashed lines represent the implicit prototype relationship; so, for example **cf<sub>3</sub>**'s prototype is **CF<sub>p</sub>**. The constructor, **CF**, has two properties itself, named **P<sub>1</sub>** and **P<sub>2</sub>**, which are not visible to **CF<sub>p</sub>**, **cf<sub>1</sub>**, **cf<sub>2</sub>**, **cf<sub>3</sub>**, **cf<sub>4</sub>**, or **cf<sub>5</sub>**. The property named **CFP<sub>1</sub>** in **CF<sub>p</sub>** is shared by: **cf<sub>1</sub>**, **cf<sub>2</sub>**, **cf<sub>3</sub>**, **cf<sub>4</sub>**, and **cf<sub>5</sub>**, as are any properties found in **CF<sub>p</sub>**'s implicit prototype chain which are not named **q<sub>1</sub>**, **q<sub>2</sub>**, or **CFP<sub>1</sub>**. Notice that there is no implicit prototype link between **CF<sub>p</sub>** and **CF**.

Unlike class-based object languages, properties can be added to objects on the fly simply by assigning values to them. That is, constructors are not required to name or assign values to all or any of its properties. In the above diagram, one could add a new shared property for **cf<sub>1</sub>**, **cf<sub>2</sub>**, **cf<sub>3</sub>**, **cf<sub>4</sub>**, and **cf<sub>5</sub>** by assigning a new value to the property in **CF<sub>p</sub>**.

### 4.3 DEFINITIONS

The following are informal definitions of key terms associated with ECMAScript.

#### 4.3.1 Type

A *type* is a set of data values. In general, the correct functioning of a program is not affected if different data values of the same type are substituted for others.

#### 4.3.2 Primitive Value

A *primitive value* is a member of one of the types **Undefined**, **Null**, **Boolean**, **Number**, or **String**. A primitive value is a datum which is represented directly at the lowest level of the language implementation.

#### 4.3.3 Object

An *object* is a member of the type **Object**. It is an unordered collection of properties which contain primitive values, objects, or functions. A function stored in the property of an object is called a method.

#### 4.3.4 Constructor

A *constructor* is a function object which creates and initializes objects. Each constructor has an associated prototype object which is used to implement inheritance and shared properties.

### 4.3.5 Prototype

A *prototype* is an object used to implement structure, state, and behavior inheritance in ECMAScript. When a constructor creates an object, that object implicitly references the constructor's associated prototype for the purpose of resolving property references. The constructor's associated prototype can be referenced by the program expression `constructor.prototype`, and properties added to an object's prototype are shared, through inheritance, by all objects sharing the prototype.

### 4.3.6 Native Object

A *native object* is any object supplied by an ECMAScript implementation independent of the host environment. Standard native objects are defined in this specification. Some native objects are built-in; others may be constructed during the course of execution of an ECMAScript program.

### 4.3.7 Built-In Object

A *built-in object* is any object supplied by an ECMAScript implementation, independent of the host environment, that is present at the start of the execution of an ECMAScript program. Standard built-in objects are defined in this specification, and the ECMAScript implementation may specify and define others. Every built-in object is a native object.

### 4.3.8 Host Object

A *host object* is any object supplied by the host environment to complete the execution environment of ECMAScript. Any object that is not native is a host object.

### 4.3.9 Undefined

**Undefined** is a primitive value used when a variable has not been assigned a value.

### 4.3.10 Undefined Type

The type **Undefined** has exactly one value, called **undefined**.

### 4.3.11 Null

**Null** is a primitive value that represents the null, empty, or nonexistent reference.

### 4.3.12 Null Type

The type **Null** has exactly one value, called **null**.

### 4.3.13 Boolean Value

A *boolean value* is a member of the type **Boolean** and is one of either two unique values, **true** and **false**.

### 4.3.14 Boolean Type

The type **Boolean** represents a logical entity and consists of exactly two unique values. One is called **true** and the other is called **false**.

### 4.3.15 Boolean Object

A *Boolean object* is a member of the type **Object** and is an instance of the Boolean object which is a constructor. That is, a boolean object is created by using the Boolean constructor in a new expression, supplying a boolean as an argument. The resulting object has an implicit (unnamed) property which is the boolean. A boolean object can be coerced to a boolean value. A boolean object can be used anywhere a boolean value is expected.

This is an example of one of the conveniences built into ECMAScript—in this case it is to accommodate programmers of varying backgrounds. Those familiar with imperative or procedural

programming languages may find number values more natural, while those familiar with object-oriented languages may find number objects more intuitive.

#### 4.3.16 String Value

A *string value* is a member of the type **String** and is the set of all finite ordered sequences of zero or more Unicode characters.

#### 4.3.17 String Type

The type **String** is the set of all finite ordered sequences of zero or more Unicode characters.

#### 4.3.18 String Object

A *string object* is a member of the type **Object** and is an instance of the **String** object which is a constructor. That is, a string object is created by using the **String** constructor in a new expression, supplying a string as an argument. The resulting object has an implicit (unnamed) property which is the string. A string object can be coerced to a string value. A string object can be used anywhere a string value is expected.

#### 4.3.19 Number Value

A *number value* is a member of the type **Number** and is a direct representation of a number.

#### 4.3.20 Number Type

The type **Number** is a set of values representing numbers. In ECMAScript the set of values represent the double-precision 64-bit format IEEE 754 value along with a special “Not-a-Number” (NaN) value, positive infinity, and negative infinity.

#### 4.3.21 Number Object

A *number object* is a member of the type **Object** and is an instance of the **Number** object which is a constructor. That is, a number object is created by using the **Number** constructor in a new expression, supplying a number as an argument. The resulting object has an implicit (unnamed) property which is the number. A number object can be coerced to a number value. A number object can be used anywhere a number value is expected. Note that a number object can have shared properties by adding them to the **Number** prototype.

#### 4.3.22 Infinity

The primitive value **Infinity** represents the positive infinite number value.

#### 4.3.23 NaN

The primitive value **NaN** represents the set of IEEE Standard “Not-a-Number” values.



## 5 NOTATIONAL CONVENTIONS

### 5.1 SYNTACTIC AND LEXICAL GRAMMARS

This section describes the context-free grammars used in this specification to define the lexical and syntactic structure of an ECMAScript program.

#### 5.1.1 Context-Free Grammars

A *context-free grammar* consists of a number of *productions*. Each production has an abstract symbol called a *nonterminal* as its *left-hand side*, and a sequence of one or more nonterminal and *terminal* symbols as its *right-hand side*. For each grammar, the terminal symbols are drawn from a specified alphabet.

Starting from a sentence consisting of a single distinguished nonterminal, called the *goal symbol*, a given context-free grammar specifies a *language*, namely, the (perhaps infinite) set of possible sequences of terminal symbols that can result from repeatedly replacing any nonterminal in the sequence with a right-hand side of a production for which the nonterminal is the left-hand side.

#### 5.1.2 The Lexical Grammar

A *lexical grammar* for ECMAScript is given in Chapter 7. This grammar has as its terminal symbols the characters of the Unicode character set. It defines a set of productions, starting from the goal symbol *Input*, that describe how sequences of Unicode characters are translated into a sequence of input elements.

Input elements other than white space and comments form the terminal symbols for the syntactic grammar for ECMAScript and are called ECMAScript *tokens*. These tokens are the reserved words, identifiers, literals, and punctuators of the ECMAScript language. Moreover, line terminators, although not considered to be tokens, also become part of the stream of input elements and guide the process of automatic semicolon insertion (see section 7.8). Simple white space and single-line comments are simply discarded and do not appear in the stream of input elements for the syntactic grammar. A multi-line comment is likewise simply discarded if it contains no line terminator; but if a multi-line comment contains one or more line terminators, then it is replaced by a single line terminator, which becomes part of the stream of input elements for the syntactic grammar.

Productions of the lexical grammar are distinguished by having two colons “:” as separating punctuation.

#### 5.1.3 The Numeric String Grammar

A second grammar is used for translating strings into numeric values. This grammar is similar to the part of the lexical grammar having to do with numeric literals and has as its terminal symbols the characters of the Unicode character set. This grammar appears in section 9.3.1.

Productions of the numeric string grammar are distinguished by having three colons “::” as punctuation.

#### 5.1.4 The Syntactic Grammar

The *syntactic grammar* for ECMAScript is given in Chapters 11, 12, 13, and 10. This grammar has ECMAScript tokens defined by the lexical grammar as its terminal symbols (see section 5.1.2). It defines a set of productions, starting from the goal symbol *Program*, that describe how sequences of tokens can form syntactically correct ECMAScript programs.

When a stream of Unicode characters is to be parsed as an ECMAScript program, it is first converted to a stream of input elements by repeated application of the lexical grammar; this stream of input elements is then parsed by a single application of the syntax grammar. The program is syntactically in error if the tokens in the stream of input elements cannot be parsed as a single instance of the goal nonterminal *program*, with no tokens left over.

Productions of the syntactic grammar are distinguished by having just one colon as punctuation.

The syntactic grammar as presented in Chapters 7, 8, 9, and 10 is actually not a complete account of which token sequences are accepted as correct ECMAScript programs. Certain additional token sequences are also accepted, namely, those that would be described by the grammar if only semicolons were added to the sequence in certain places (such as before end-of-line characters). Furthermore, certain token sequences that are described by the grammar are not considered acceptable if an end-of-line character appears in certain “awkward” places.

A LALR(1) version of the syntactic grammar is presented in Appendix E. This version provides an exact account of which token sequences are acceptable ECMAScript programs without needing special rules about automatically adding semicolons or forbidding end-of-line characters. However, it is much more complex than the grammar presented in Chapters 7, 8, 9, and 10.

### 5.1.5 Grammar Notation

Terminal symbols of the lexical and string grammars, and some of the terminal symbols of the syntactic grammar, are shown in **fixed width** font, both in the productions of the grammars and throughout this specification whenever the text directly refers to such a terminal symbol. These are to appear in a program exactly as written.

Nonterminal symbols are shown in *italic* type. The definition of a nonterminal is introduced by the name of the nonterminal being defined followed by one or more colons. (The number of colons indicates to which grammar the production belongs.) One or more alternative right-hand sides for the nonterminal then follow on succeeding lines. For example, the syntactic definition:

*WithStatement* :  
**with** ( *Expression* ) *Statement*

states that the nonterminal *WithStatement* represents the token **with**, followed by a left parenthesis token, followed by an *Expression*, followed by a right parenthesis token, followed by a *Statement*. The occurrences of *Expression* and *Statement* are themselves nonterminals. As another example, the syntactic definition:

*ArgumentList* :  
*AssignmentExpression*  
*ArgumentList* , *AssignmentExpression*

states that an *ArgumentList* may represent either a single *AssignmentExpression* or an *ArgumentList*, followed by a comma, followed by an *AssignmentExpression*. This definition of *ArgumentList* is *recursive*, that is to say, it is defined in terms of itself. The result is that an *ArgumentList* may contain any positive number of arguments, separated by commas, where each argument expression is an *AssignmentExpression*. Such recursive definitions of nonterminals are common.

The subscripted suffix “*opt*”, which may appear after a terminal or nonterminal, indicates an *optional symbol*. The alternative containing the optional symbol actually specifies two right-hand sides, one that omits the optional element and one that includes it. This means that:

*VariableDeclaration* :  
*Identifier* *Initializer*<sub>*opt*</sub>

is a convenient abbreviation for:

*VariableDeclaration* :  
*Identifier*  
*Identifier* *Initializer*

and that:

*IterationStatement* :  
**for** ( *Expression*<sub>opt</sub> ; *Expression*<sub>opt</sub> ; *Expression*<sub>opt</sub> ) *Statement*

is a convenient abbreviation for:

*IterationStatement* :  
**for** ( ; *Expression*<sub>opt</sub> ; *Expression*<sub>opt</sub> ) *Statement*  
**for** ( *Expression* ; *Expression*<sub>opt</sub> ; *Expression*<sub>opt</sub> ) *Statement*

which in turn is an abbreviation for:

*IterationStatement* :  
**for** ( ; ; *Expression*<sub>opt</sub> ) *Statement*  
**for** ( ; *Expression* ; *Expression*<sub>opt</sub> ) *Statement*  
**for** ( *Expression* ; ; *Expression*<sub>opt</sub> ) *Statement*  
**for** ( *Expression* ; *Expression* ; *Expression*<sub>opt</sub> ) *Statement*

which in turn is an abbreviation for:

*IterationStatement* :  
**for** ( ; ; ) *Statement*  
**for** ( ; ; *Expression* ) *Statement*  
**for** ( ; *Expression* ; ) *Statement*  
**for** ( ; *Expression* ; *Expression* ) *Statement*  
**for** ( *Expression* ; ; ) *Statement*  
**for** ( *Expression* ; ; *Expression* ) *Statement*  
**for** ( *Expression* ; *Expression* ; ) *Statement*  
**for** ( *Expression* ; *Expression* ; *Expression* ) *Statement*

so the nonterminal *IterationStatement* actually has eight alternative right-hand sides.

If the phrase “[no *LineTerminator* here]” appears in the right-hand side of a production of the syntactic grammar, it indicates that the production is a *restricted production*: it may not be used if a *LineTerminator* occurs in the input stream at the indicated position. For example, the production:

*ReturnStatement* :  
**return** [no *LineTerminator* here] *Expression*<sub>opt</sub> ;

indicates that the production may not be used if a *LineTerminator* occurs in the program between the **return** token and the *Expression*.

Unless the presence of a *LineTerminator* is forbidden by a restricted production, any number of occurrences of *LineTerminator* may appear between any two consecutive tokens in the stream of input elements without affecting the syntactic acceptability of the program.

When the words “**one of**” follow the colon(s) in a grammar definition, they signify that each of the terminal symbols on the following line or lines is an alternative definition. For example, the lexical grammar for ECMAScript contains the production:

*ZeroToThree* :: **one of**  
                  0                                  1                                  2                                  3

which is merely a convenient abbreviation for:

*ZeroToThree* ::  
0  
1  
2  
3

When an alternative in a production of the lexical grammar or the numeric string grammar appears to be a multicharacter token, it represents the sequence of characters that would make up such a token.

The right-hand side of a production may specify that certain expansions are not permitted by using the phrase “**but not**” and then indicating the expansions to be excluded. For example, the production:

*Identifier* ::  
*IdentifierName* **but not** *ReservedWord*

means that the nonterminal *Identifier* may be replaced by any sequence of characters that could replace *IdentifierName* provided that the same sequence of characters could not replace *ReservedWord*.

Finally, a few nonterminal symbols are described by a descriptive phrase in roman type in cases where it would be impractical to list all the alternatives:

*SourceCharacter*:  
any Unicode character

## 5.2 ALGORITHM CONVENTIONS

We often use a numbered list to specify steps in an algorithm. When the algorithm is to produce a value as a result, we use the directive “return  $x$ ” to indicate that the result of the algorithm is the value of  $x$  and that the algorithm should terminate. We use the notation  $\text{Result}(n)$  as shorthand for “the result of step  $n$ ”. We also use  $\text{Type}(x)$  as shorthand for “the type of  $x$ ”.

Mathematical operations such as addition, subtraction, multiplication, and division should always be understood as computing exact mathematical results. Algorithms that model floating-point arithmetic include explicit steps to perform rounding, where necessary.

The mathematical function  $\text{abs}(x)$  yields the absolute value of  $x$ , which is  $-x$  if  $x$  is negative (less than zero) and otherwise is  $x$  itself.

The mathematical function  $\text{sign}(x)$  yields 1 if  $x$  is positive and  $-1$  if  $x$  is negative. The sign function is not used in this document for cases when  $x$  is zero.

The notation “ $x$  modulo  $y$ ” ( $y$  must be a finite and nonzero) computes a value  $k$  of the same sign as  $y$  such that  $\text{abs}(k) < \text{abs}(y)$  and  $x - k = q \cdot y$  for some integer  $q$ .

The mathematical function  $\text{floor}(x)$  yields the largest integer (closest to positive infinity) that is not larger than  $x$ . Note that  $\text{floor}(x) = x - (x \text{ modulo } 1)$ .

If an algorithm is defined to “generate a runtime error”, execution of the algorithm (and any calling algorithms) is terminated and no result is returned.

These algorithms are used to clarify semantics. In practice, there may be more efficient algorithms available to implement a given feature.

## 6 SOURCE TEXT

ECMAScript source text is represented as a sequence of characters representable using the Unicode version 2.0 character encoding

*SourceCharacter*::  
any Unicode character

However, it is possible to represent every ECMAScript program using only ASCII characters (which are equivalent to the first 128 Unicode characters). Non-ASCII Unicode characters may appear only within comments and string literals. In string literals, any Unicode character may also be expressed as a Unicode escape sequence consisting of six ASCII characters, namely `\u` plus four hexadecimal digits. (Within a comment, such an escape sequence is effectively ignored as part of the comment. Within a string literal, the Unicode escape sequence contributes one character to the string value of the literal.

Note that ECMAScript differs from the Java programming language in the behavior of Unicode escape sequences. In a Java program, if the Unicode escape sequence `\u000A`, for example, occurs within a single-line comment, it is interpreted as a line terminator (Unicode character `000A` is line feed) and therefore the next character is not part of the comment. Similarly, if the Unicode escape sequence `\u000A` occurs within a string literal in a Java program, it is likewise interpreted as a line terminator, which is not allowed within a string literal—one must write `\n` instead of `\u000A` to cause a line feed to be part of the string value of a string literal. In an ECMAScript program, a Unicode escape sequence occurring within a comment is never interpreted and therefore cannot contribute to termination of the comment. Similarly, a Unicode escape sequence occurring within a string literal in an ECMAScript program always contributes a character to the string value of the literal and is never interpreted as a line terminator or as a quote mark that might terminate the string literal.

## 7 LEXICAL CONVENTIONS

The source text of a ECMAScript program is first converted into a sequence of tokens and white space. A token is a sequence of characters that comprise a lexical unit. The source text is scanned from left to right, repeatedly taking the longest possible sequence of characters as the next token.

### 7.1 WHITE SPACE

White space characters are used to improve source text readability and to separate tokens (indivisible lexical units) from each other but are otherwise insignificant. White space may occur between any two tokens, and may occur within strings (where they are considered significant characters forming part of the literal string value), but cannot appear within any other kind of token.

The following characters are considered to be white space:

<i>Unicode Value</i>	<i>Name</i>	<i>Formal Name</i>
\u0009	Tab	<TAB>
\u000B	Vertical Tab	<VT>
\u000C	Form Feed	<FF>
\u0020	Space	<SP>

#### Syntax

```
WhiteSpace ::  
    <TAB>  
    <VT>  
    <FF>  
    <SP>
```

### 7.2 LINE TERMINATORS

Line terminator characters, like whitespace characters, are used to improve source text readability and to separate tokens (indivisible lexical units) from each other. Unlike whitespace characters, line terminators have some influence over the behavior of the syntactic grammar. In general, line terminators may occur between any two tokens, but there are a few places where they are forbidden by the syntactic grammar. A line terminator cannot occur within any token (not even a string). Line terminators also affect the process of automatic semicolon insertion (see section 10).

The following characters are considered to be line terminators

<i>Unicode Value</i>	<i>Name</i>	<i>Formal Name</i>
\u000A	Line Feed	<LF>
\u000D	Carriage Return	<CR>

#### Syntax

```
LineTerminator ::  
    <LF>  
    <CR>
```

## 7.3 COMMENTS

### Description

Comments can be either single or multi-line. Multi-line comments cannot nest.

Because a single-line comment can contain any character except *LineTerminator* character, and because of the general rule that a token is always as long as possible, a single-line comment always consists of all characters from the *//* marker to the end of the line. However, the *LineTerminator* at the end of the line is not considered to be part of the single-line comment; it is recognized separately by the lexical grammar and becomes part of the stream of input elements for the syntactic grammar. This point is very important, because it implies that the presence or absence of single-line comments does not affect the process of automatic semicolon insertion (see section 9).

### Syntax

*Comment* ::

*MultiLineComment*

*SingleLineComment*

*MultiLineComment* ::

*/\* MultiLineCommentChar*<sub>opt</sub> *\*/*

*MultiLineCommentChars* ::

*MultiLineNotAsteriskChar* *MultiLineCommentChar*<sub>opt</sub>

*\* PostAsteriskCommentChar*<sub>opt</sub>

*PostAsteriskCommentChars* ::

*MultiLineNotForwardSlashOrAsteriskChar* *MultiLineCommentChar*<sub>opt</sub>

*\* PostAsteriskCommentChar*<sub>opt</sub>

*MultiLineNotAsteriskChar* :

*SourceCharacter* **but not** *asterisk* **\***

*MultiLineNotForwardSlashOrAsteriskChar* ::

*SourceCharacter* **but not** *forward-slash /* **or** *asterisk* **\***

*SingleLineComment* ::

*// SingleLineCommentChar*<sub>opt</sub>

*SingleLineCommentChars* ::

*SingleLineCommentChar* *SingleLineCommentChar*<sub>opt</sub>

*SingleLineCommentChar* ::

*SourceCharacter* **but not** *LineTerminator*

## 7.4 TOKENS

### Syntax

*Token* ::

*ReservedWord*

*Identifier*

*Punctuator*

*Literal*

### 7.4.1 Reserved Words

#### Description

Reserved words cannot be used as identifiers.

*ReservedWord*::  
*Keyword*  
*FutureReservedWord*  
*NullLiteral*  
*BooleanLiteral*

## 7.4.2 Keywords

The following tokens are ECMAScript keywords and may not be used as identifiers in ECMAScript programs.

### Syntax

*Keyword*: one of

<b>break</b>	<b>for</b>	<b>new</b>	<b>var</b>
<b>continue</b>	<b>function</b>	<b>return</b>	<b>void</b>
<b>delete</b>	<b>if</b>	<b>this</b>	<b>while</b>
<b>else</b>	<b>in</b>	<b>typeof</b>	<b>with</b>

## 7.4.3 Future Reserved Words

The following words are used as keywords in proposed extensions and are therefore reserved to allow for the possibility of future adoption of those extensions.

### Syntax

*FutureReservedWord*: one of

<b>case</b>	<b>debugger</b>	<b>export</b>	<b>super</b>
<b>catch</b>	<b>default</b>	<b>extends</b>	<b>switch</b>
<b>class</b>	<b>do</b>	<b>finally</b>	<b>throw</b>
<b>const</b>	<b>enum</b>	<b>import</b>	<b>try</b>

## 7.5 IDENTIFIERS

### Description

An identifier is a character sequence of unlimited length, where each character in the sequence must be a letter, a decimal digit, an underscore (`_`) character, or a dollar sign (`$`) character, and the first character may not be a decimal digit. ECMAScript identifiers are case sensitive: identifiers whose characters differ in any way, even if only in case, are considered to be distinct.

### Syntax

*Identifier*::  
*IdentifierName* **but not** *ReservedWord*

*IdentifierName*::  
*IdentifierLetter*  
*IdentifierName* *IdentifierLetter*  
*IdentifierName* *DecimalDigit*

*IdentifierLetter*:: one of

<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>	<b>e</b>	<b>f</b>	<b>g</b>	<b>h</b>	<b>i</b>	<b>j</b>	<b>k</b>	<b>l</b>	<b>m</b>	<b>n</b>	<b>o</b>	<b>p</b>	<b>q</b>	<b>r</b>	<b>s</b>	<b>t</b>	<b>u</b>	<b>v</b>	<b>w</b>	<b>x</b>	<b>y</b>	<b>z</b>
<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>	<b>H</b>	<b>I</b>	<b>J</b>	<b>K</b>	<b>L</b>	<b>M</b>	<b>N</b>	<b>O</b>	<b>P</b>	<b>Q</b>	<b>R</b>	<b>S</b>	<b>T</b>	<b>U</b>	<b>V</b>	<b>W</b>	<b>X</b>	<b>Y</b>	<b>Z</b>
<b>\$</b>	<b>_</b>																								

*DecimalDigit*:: one of

<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
----------	----------	----------	----------	----------	----------	----------	----------	----------	----------



## 7.6 PUNCTUATORS

### Syntax

*Punctuator* :: one of

=	>	<	==	<=	>=
!=	,	!	~	?	:
.	&&		++	--	+
-	*	/	&		^
%	<<	>>	>>>	+=	--
*=	/=	&=	=	^=	%=
<<=	>>=	>>>=	(	)	{
}	[	]	;		

## 7.7 LITERALS

### Syntax

*Literal* ::

*NullLiteral*  
*BooleanLiteral*  
*NumericLiteral*  
*StringLiteral*

### 7.7.1 Null Literals

#### Syntax

*NullLiteral* ::  
**null**

#### Semantics

The value of the null literal **null** is the sole value of the Null type, namely **null**.

### 7.7.2 Boolean Literals

#### Syntax

*BooleanLiteral* ::  
**true**  
**false**

#### Semantics

The value of the Boolean literal **true** is a value of the Boolean type, namely **true**.

The value of the Boolean literal **false** is a value of the Boolean type, namely **false**.

### 7.7.3 Numeric Literals

#### Syntax

*NumericLiteral* ::  
*DecimalLiteral*  
*HexIntegerLiteral*  
*OctalIntegerLiteral*

*DecimalLiteral* ::  
*DecimalIntegerLiteral*  
*DecimalIntegerLiteral* . *DecimalDigits*<sub>opt</sub> *ExponentPart*<sub>opt</sub>  
 . *DecimalDigits* *ExponentPart*<sub>opt</sub>  
*DecimalIntegerLiteral* *ExponentPart*

*DecimalIntegerLiteral*::  
 0  
*NonZeroDigit DecimalDigits<sub>opt</sub>*

*DecimalDigits* ::  
*DecimalDigit*  
*DecimalDigits DecimalDigit*

*NonZeroDigit* :: **one of**  
 1 2 3 4 5 6 7 8 9

*ExponentPart* ::  
*ExponentIndicator SignedInteger*

*ExponentIndicator* :: **one of**  
 e E

*SignedInteger* ::  
*DecimalDigits*  
 + *DecimalDigits*  
 - *DecimalDigits*

*HexIntegerLiteral*::  
 0x *HexDigit*  
 0X *HexDigit*  
*HexIntegerLiteral HexDigit*

*HexDigit* :: **one of**  
 0 1 2 3 4 5 6 7 8 9 a b c d e f A B C D E F

*OctalIntegerLiteral*::  
 0 *OctalDigit*  
*OctalLiteral OctalDigit*

*OctalDigit* :: **one of**  
 0 1 2 3 4 5 6 7

## Semantics

A numeric literal stands for a value of the Number type. This value is determined in two steps: first, a mathematical value (MV) is derived from the literal; second, this mathematical value is rounded, ideally using IEEE 754 round-to-nearest mode, to a representable value of the number type.

- The MV of *NumericLiteral* :: *DecimalLiteral* is the MV of *DecimalLiteral*.
- The MV of *NumericLiteral* :: *HexIntegerLiteral* is the MV of *HexIntegerLiteral*.
- The MV of *NumericLiteral* :: *OctalIntegerLiteral* is the MV of *OctalIntegerLiteral*.
- The MV of *DecimalLiteral* :: *DecimalIntegerLiteral* is the MV of *DecimalIntegerLiteral*.
- The MV of *DecimalLiteral* :: *DecimalIntegerLiteral* . is the MV of *DecimalIntegerLiteral*.
- The MV of *DecimalLiteral* :: *DecimalIntegerLiteral* . *DecimalDigits* is the MV of *DecimalIntegerLiteral* plus (the MV of *DecimalDigits* times  $10^n$ ), where  $n$  is the number of characters in *DecimalDigits*.
- The MV of *DecimalLiteral* :: *DecimalIntegerLiteral* . *ExponentPart* is the MV of *DecimalIntegerLiteral* times  $10^e$ , where  $e$  is the MV of *ExponentPart*.
- The MV of *DecimalLiteral* :: *DecimalIntegerLiteral* . *DecimalDigits ExponentPart* is (the MV of *DecimalIntegerLiteral* plus (the MV of *DecimalDigits* times  $10^n$ )) times  $10^e$ , where  $n$  is the number of characters in *DecimalDigits* and  $e$  is the MV of *ExponentPart*.
- The MV of *DecimalLiteral* :: . *DecimalDigits* is the MV of *DecimalDigits* times  $10^{-n}$ , where  $n$  is the number of characters in *DecimalDigits*.
- The MV of *DecimalLiteral* :: . *DecimalDigits ExponentPart* is the MV of *DecimalDigits* times  $10^{-n}$ , where  $n$  is the number of characters in *DecimalDigits* and  $e$  is the MV of *ExponentPart*.

- The MV of *DecimalLiteral :: DecimalIntegerLiteral ExponentPart* is the MV of *DecimalIntegerLiteral* times  $10^e$ , where  $e$  is the MV of *ExponentPart*.
- The MV of *DecimalIntegerLiteral :: 0* is 0.
- The MV of *DecimalIntegerLiteral :: NonZeroDigit DecimalDigits* is (the MV of *NonZeroDigit* times  $10^n$ ) plus the MV of *DecimalDigits*, where  $n$  is the number of characters in *DecimalDigits*.
- The MV of *DecimalDigits :: DecimalDigit* is the MV of *DecimalDigit*.
- The MV of *DecimalDigits :: DecimalDigits DecimalDigit* is (the MV of *DecimalDigits* times 10) plus the MV of *DecimalDigit*.
- The MV of *ExponentPart :: ExponentIndicator SignedInteger* is the MV of *SignedInteger*.
- The MV of *SignedInteger :: DecimalDigits* is the MV of *DecimalDigits*.
- The MV of *SignedInteger :: + DecimalDigits* is the MV of *DecimalDigits*.
- The MV of *SignedInteger :: - DecimalDigits* is the negative of the MV of *DecimalDigits*.
- The MV of *DecimalDigit :: 0* or of *HexDigit :: 0* or of *OctalDigit :: 0* is 0.
- The MV of *DecimalDigit :: 1* or of *NonZeroDigit :: 1* or of *HexDigit :: 1* or of *OctalDigit :: 1* is 1.
- The MV of *DecimalDigit :: 2* or of *NonZeroDigit :: 2* or of *HexDigit :: 2* or of *OctalDigit :: 2* is 2.
- The MV of *DecimalDigit :: 3* or of *NonZeroDigit :: 3* or of *HexDigit :: 3* or of *OctalDigit :: 3* is 3.
- The MV of *DecimalDigit :: 4* or of *NonZeroDigit :: 4* or of *HexDigit :: 4* or of *OctalDigit :: 4* is 4.
- The MV of *DecimalDigit :: 5* or of *NonZeroDigit :: 5* or of *HexDigit :: 5* or of *OctalDigit :: 5* is 5.
- The MV of *DecimalDigit :: 6* or of *NonZeroDigit :: 6* or of *HexDigit :: 6* or of *OctalDigit :: 6* is 6.
- The MV of *DecimalDigit :: 7* or of *NonZeroDigit :: 7* or of *HexDigit :: 7* or of *OctalDigit :: 7* is 7.
- The MV of *DecimalDigit :: 8* or of *NonZeroDigit :: 8* or of *HexDigit :: 8* is 8.
- The MV of *DecimalDigit :: 9* or of *NonZeroDigit :: 9* or of *HexDigit :: 9* is 9.
- The MV of *HexDigit :: a* or of *HexDigit :: A* is 10.
- The MV of *HexDigit :: b* or of *HexDigit :: B* is 11.
- The MV of *HexDigit :: c* or of *HexDigit :: C* is 12.
- The MV of *HexDigit :: d* or of *HexDigit :: D* is 13.
- The MV of *HexDigit :: e* or of *HexDigit :: E* is 14.
- The MV of *HexDigit :: f* or of *HexDigit :: F* is 15.
- The MV of *HexIntegerLiteral :: 0x HexDigit* is the MV of *HexDigit*.
- The MV of *HexIntegerLiteral :: 0X HexDigit* is the MV of *HexDigit*.
- The MV of *HexIntegerLiteral :: HexIntegerLiteral HexDigit* is (the MV of *HexIntegerLiteral* times 16) plus the MV of *HexDigit*.
- The MV of *OctalIntegerLiteral :: 0 OctalDigit* is the MV of *OctalDigit*.
- The MV of *OctalIntegerLiteral :: OctalIntegerLiteral OctalDigit* is (the MV of *OctalIntegerLiteral* times 8) plus the MV of *OctalDigit*.

Once the exact MV for a numeric literal has been determined, it is then rounded to a value of the Number type. If the MV is 0, then the rounded value is  $\pm 0$ ; otherwise, the rounded value must be the number value for the MV (in the sense defined in section 8.4), unless the literal is a *DecimalLiteral* and the literal has more than 20 significant digits, in which case the number value may be any implementation-dependent approximation to the MV. A digit is *significant* if it is not part of an *ExponentPart* and (either it is not 0 or it is an *important zero* or there is no decimal point '.' in the literal). A digit 0 is an *important zero* if there is at least one important item to its left and at least one important item to its right within the literal. Any digit that is not 0 and is not part of an *ExponentPart* is an important item.

#### 7.7.4 String Literals

A string literal is zero or more characters enclosed in single or double quotes. Each character may be represented by an escape sequence.

##### Syntax

```
StringLiteral ::
    " DoubleStringCharactersopt "
    ' SingleStringCharactersopt '
```

*DoubleStringCharacters* ::  
*DoubleStringCharacter DoubleStringCharacters*<sub>pt</sub>

*SingleStringCharacters* ::  
*SingleStringCharacter SingleStringCharacters*<sub>pt</sub>

*DoubleStringCharacter* ::  
*SourceCharacter* **but not** *double-quote " or backslash \ or LineTerminator*  
*EscapeSequence*

*SingleStringCharacter* ::  
*SourceCharacter* **but not** *single-quote ' or backslash \ or LineTerminator*  
*EscapeSequence*

*EscapeSequence* ::  
*CharacterEscapeSequence*  
*OctalEscapeSequence*  
*HexEscapeSequence*  
*UnicodeEscapeSequence*

*CharacterEscapeSequence* ::  
 \ *SingleEscapeCharacter*  
 \ *NonEscapeCharacter*

*SingleEscapeCharacter* :: **one of**  
 ' " \ **b f n r t**

*NonEscapeCharacter* ::  
*SourceCharacter* **but not** *EscapeCharacter or LineTerminator*

*EscapeCharacter* ::  
*SingleEscapeCharacter*  
*OctalDigit*  
**x**  
**u**

*HexEscapeSequence* ::  
 \**x** *HexDigit HexDigit*

*OctalEscapeSequence* ::  
 \ *OctalDigit*  
 \ *OctalDigit OctalDigit*  
 \ *ZeroToThree OctalDigit OctalDigit*

*ZeroToThree* :: **one of**  
**0 1 2 3**

*UnicodeEscapeSequence* ::  
 \**u** *HexDigit HexDigit HexDigit HexDigit*

The definitions of the nonterminals *HexDigit* and *OctalDigit* are given in section 7.7.3.

A string literal stands for a value of the *String* type. The string value (SV) of the literal is described in terms of character values (CV) contributed by the various parts of the string literal. As part of this process, some characters within the string literal are interpreted as having a mathematical value (MV), as described below or in section 7.7.3

- The SV of *StringLiteral* :: "" is the empty character sequence .
- The SV of *StringLiteral* :: ' ' is the empty character sequence.
- The SV of *StringLiteral* :: " *DoubleStringCharacters* " is the SV of *DoubleStringCharacters*.

- The SV of *StringLiteral*:: ' *SingleStringCharacters* ' is the SV of *SingleStringCharacters*.
- The SV of *DoubleStringCharacters*:: *DoubleStringCharacter* is a sequence of one character, the CV of *DoubleStringCharacter*.
- The SV of *DoubleStringCharacters*:: *DoubleStringCharacter DoubleStringCharacters* is a sequence of the CV of *DoubleStringCharacter* followed by all the characters in the SV of *DoubleStringCharacters* in order.
- The SV of *SingleStringCharacters*:: *SingleStringCharacter* is a sequence of one character, the CV of *SingleStringCharacter*.
- The SV of *SingleStringCharacters*:: *SingleStringCharacter SingleStringCharacters* is a sequence of the CV of *SingleStringCharacter* followed by all the characters in the SV of *SingleStringCharacters* in order.
- The CV of *DoubleStringCharacter*:: *SourceCharacter* **but not double-quote " or backslash \ or LineTerminator** is the *SourceCharacter* character itself.
- The CV of *DoubleStringCharacter*:: *EscapeSequence* is the CV of the *EscapeSequence*.
- The CV of *SingleStringCharacter*:: *SourceCharacter* **but not single-quote ' or backslash \ or LineTerminator** is the *SourceCharacter* character itself.
- The CV of *SingleStringCharacter*:: *EscapeSequence* is the CV of the *EscapeSequence*.
- The CV of *EscapeSequence*:: *CharacterEscapeSequence* is the CV of the *CharacterEscapeSequence*.
- The CV of *EscapeSequence*:: *OctalEscapeSequence* is the CV of the *OctalEscapeSequence*.
- The CV of *EscapeSequence*:: *HexEscapeSequence* is the CV of the *HexEscapeSequence*.
- The CV of *EscapeSequence*:: *UnicodeEscapeSequence* is the CV of the *UnicodeEscapeSequence*.
- The CV of *CharacterEscapeSequence*:: \ *SingleEscapeCharacter* is the Unicode character whose Unicode value is determined by the *SingleEscapeCharacter* according to the following table:

<i>Escape Sequence</i>	<i>Unicode Value</i>	<i>Name</i>	<i>Symbol</i>
<code>\b</code>	<code>\u0008</code>	backspace	<BS>
<code>\t</code>	<code>\u0009</code>	horizontal tab	<HT>
<code>\n</code>	<code>\u000A</code>	line feed (new line)	<LF>
<code>\f</code>	<code>\u000C</code>	form feed	<FF>
<code>\r</code>	<code>\u000D</code>	carriage return	<CR>
<code>\"</code>	<code>\u0022</code>	double quote	"
<code>\'</code>	<code>\u0027</code>	single quote	'
<code>\\</code>	<code>\u005C</code>	backslash	\

- The CV of *CharacterEscapeSequence*:: \ *NonEscapeCharacter* is the CV of the *NonEscapeCharacter*.
- The CV of *NonEscapeCharacter*:: *SourceCharacter* **but not EscapeCharacter or LineTerminator** is the *SourceCharacter* character itself.
- The CV of *HexEscapeSequence*:: \ *HexDigit HexDigit* is the Unicode character whose code is (16 times the MV of the first *HexDigit*) plus the MV of the second *HexDigit*.
- The CV of *OctalEscapeSequence*:: \ *OctalDigit* is the Unicode character whose code is the MV of the *OctalDigit*.
- The CV of *OctalEscapeSequence*:: \ *OctalDigit OctalDigit* is the Unicode character whose code is (8 times the MV of the first *OctalDigit*) plus the MV of the second *OctalDigit*.
- The CV of *OctalEscapeSequence*:: \ *ZeroToThree OctalDigit OctalDigit* is the Unicode character whose code is (64 (that is, 8<sup>2</sup>) times the MV of the *ZeroToThree*) plus (8 times the MV of the first *OctalDigit*) plus the MV of the second *OctalDigit*.
- The MV of *ZeroToThree*:: 0 is 0.
- The MV of *ZeroToThree*:: 1 is 1.
- The MV of *ZeroToThree*:: 2 is 2.
- The MV of *ZeroToThree*:: 3 is 3.

- The CV of *UnicodeEscapeSequence*:: `\u HexDigit HexDigit HexDigit HexDigit` is the Unicode character whose code is (4096 (that is,  $16^2$ ) times the MV of the first *HexDigit*) plus (256 (that is,  $16^1$ ) times the MV of the second *HexDigit*) plus (16 times the MV of the third *HexDigit*) plus the MV of the fourth *HexDigit*.

Note that a *LineTerminator* character cannot appear in a string literal, even if preceded by a backslash `\`. The correct way to cause a line terminator character to be part of the string value of a string literal is to use an escape sequence such as `\n` or `\u000A`.

## 7.8 AUTOMATIC SEMICOLON INSERTION

### Description

Certain ECMAScript statements (empty statement, variable statement, expression statement, **continue** statement, **break** statement, and **return** statement) must each be terminated with a semicolon. Such a semicolon may always appear explicitly in the source text. For convenience, however, such semicolons may be omitted from the source text in certain situations. We describe such situations by saying that semicolons are automatically inserted into the source code token stream in those situations:

- When, as the program is parsed from left to right, a token (called the *offending token*) is encountered that is not allowed by any production of the grammar and the parser is not currently parsing the header of a **for** statement, then a semicolon is automatically inserted before the offending token if one or more of the following conditions is true
  1. The offending token is separated from the previous token by at least one *LineTerminator*.
  2. The offending token is `}`.
- When, as the program is parsed from left to right, the end of the input stream of tokens is encountered and the parser is unable to parse the input token stream as a single complete ECMAScript *Program*, then a semicolon is automatically inserted at the end of the input stream.

However, there is an additional overriding condition on the preceding rules: a semicolon is never inserted automatically if the semicolon would then be parsed as an empty statement.

- When, as the program is parsed from left to right, a token is encountered that is allowed by some production of the grammar, but the production is a *restricted production* and the token would be the first token for a terminal or nonterminal immediately following the annotation “[no *LineTerminator* here]” within the restricted production (and therefore such a token is called a restricted token), and the restricted token is separated from the previous token by at least one *LineTerminator*, then there are two cases:
  1. If the parser is not currently parsing the header of a **for** statement, a semicolon is automatically inserted before the restricted token.
  2. If the parser is currently parsing the header of a **for** statement, it is a syntax error.

These are all the restricted productions in the grammar:

*MemberExpression* :

**new** *MemberExpression* [no *LineTerminator* here] *Arguments*

*CallExpression* :

*MemberExpression* [no *LineTerminator* here] *Arguments*

*CallExpression* [no *LineTerminator* here] *Arguments*

*PostfixExpression* :

*LeftHandSideExpression* [no *LineTerminator* here] **++**

*LeftHandSideExpression* [no *LineTerminator* here] **--**

*ReturnStatement* :

**return** [no *LineTerminator* here] *Expression<sub>opt</sub>* **;**

The practical effect of these restricted productions is as follows:

1. When the token `(` is encountered where the parser would treat it as the first token of a parenthesized *Arguments* list, and at least one *LineTerminator* occurred between the preceding token and the `(` token, then a semicolon is automatically inserted before the `(` token.
2. When the token `++` or `--` is encountered where the parser would treat it as a postfix operator, and at least one *LineTerminator* occurred between the preceding token and the `++` or `--` token, then a semicolon is automatically inserted before the `++` or `--` token.
3. When the token `return` is encountered and a *LineTerminator* is encountered before the next token is encountered, a semicolon is automatically inserted after the token `return`.

The resulting practical advice to ECMAScript programmers is:

1. The `(` that starts an argument list should be on the same line as the expression that indicates the function to be called.
2. A postfix `++` or `--` operator should appear on the same line as its operand.
3. An *Expression* in a `return` statement should start on the same line as the `return` token.

For example, the source

```
{ 1 2 } 3
```

is not a valid sentence in the ECMAScript grammar even with the automatic semicolon insertion rules. In contrast, the source

```
{ 1
 2 } 3
```

is also not a valid ECMAScript sentence, but is transformed by automatic semicolon insertion into the following:

```
{ 1
;2 ;} 3;
```

which is a valid ECMAScript sentence.

The source

```
for (a; b
)
```

is not a valid ECMAScript sentence and is not altered by automatic semicolon insertion because the place where a semicolon is needed is within the header of a `for` statement. Automatic semicolon insertion never occurs within the header of a `for` statement.

The source

```
return
a + b
```

is transformed by automatic semicolon insertion into the following:

```
return;
a + b;
```

Note that the expression `a + b` is not treated as a value to be returned by the `return` statement, because a *LineTerminator* separates it from the token `return`.

The source

```
a = b
++c
```

is transformed by automatic semicolon insertion into the following:

```
a = b;
++c;
```

Note that the token `++` is not treated as a postfix operator applying to the variable `b`, because a *LineTerminator* occurs between `b` and `++`.

The source

```
if (a > b)
else c = d
```

is not a valid ECMAScript sentence and is not altered by automatic semicolon insertion before the `else` token, even though no production of the grammar applies at that point, because an automatically inserted semicolon would then be parsed as an empty statement.

## 8 TYPES

A value is an entity that takes on one of five types. There are six standard types (**Undefined**, **Null**, **Boolean**, **String**, **Number**, and **Object**) and three internal types called **Reference**, **List**, and **Completion**. Values of type **Reference**, **List**, and **Completion** are used only as intermediate results of expression evaluation and cannot be stored to properties of objects.

### 8.1 THE UNDEFINED TYPE

The Undefined type has exactly one value, called **undefined**. Any variable that has not been assigned a value is of type Undefined.

### 8.2 THE NULL TYPE

The Null type has exactly one value, called **null**.

### 8.3 THE BOOLEAN TYPE

The Boolean type represents a logical entity and consists of exactly two unique values. One is called **true** and the other is called **false**.

### 8.4 THE STRING TYPE

The String type is the set of all finite ordered sequences of zero or more Unicode characters. Each character is regarded as occupying a position within the sequence. These positions are identified by nonnegative integers. The leftmost character (if any) is at position 0, the next character (if any) at position 1, and so on. The length of a string is the number of distinct positions within it. The empty string has length zero and therefore contains no characters.

### 8.5 THE NUMBER TYPE

The Number type has exactly  $2^{64} - 2^{53} + 3$  values, representing the double-precision 64-bit format IEEE 754 values as specified in the IEEE Standard for Binary Floating-Point Arithmetic, except that the  $2^{53} - 2$  distinct “Not-a-Number” values of the IEEE Standard are represented in ECMAScript as a single special **NaN** value. (Note that the NaN value is produced by the program expression **NaN**, assuming that the globally defined variable **NaN** has not been altered by program execution.) In some implementations, external code might be able to detect a difference between various Non-a-Number values, but such behavior is implementation-dependent; to ECMAScript code, all NaN values are the same.

There are two other special values, called **positive Infinity** and **negative Infinity**. For brevity, these values are also referred to for expository purposes by the symbols  $+\infty$  and  $-\infty$ , respectively. (Note that these two infinite number values are produced by the program expressions **Infinity** (or simply **Infinity**) and **-Infinity**, assuming that the globally defined variable **Infinity** has not been altered by program execution.)

The other  $2^{64} - 2^{53}$  values are called the finite numbers. Half of these are positive numbers and half are negative numbers; for every finite positive number there is a corresponding negative number having the same magnitude.

Note that there is both a **positive zero** and a **negative zero**. For brevity, these values are also referred to for expository purposes by the symbols **+0** and **-0**, respectively. (Note that these two zero number values are produced by the program expressions **+0** (or simply **0**) and **-0**.)



The 18437736874454810622 (that is,  $2^{64}-2^{53}-2$ ) finite nonzero values are of two kinds: 18428729675200069632 (that is,  $2^{64}-2^{54}$ ) of them are normalized, having the form

$$s \cdot m \cdot 2^e$$

where  $s$  is  $+1$  or  $-1$ ,  $m$  is a positive integer less than  $2^{53}$  but not less than  $2^{52}$ , and  $e$  is an integer ranging from  $-1074$  to  $971$ , inclusive.

The remaining 9007199254740990 (that is,  $2^{53}-2$ ) values are denormalized, having the form

$$s \cdot m \cdot 2^e$$

where  $s$  is  $+1$  or  $-1$ ,  $m$  is a positive integer less than  $2^{52}$ , and  $e$  is  $-1074$ .

Note that all the positive and negative integers whose magnitude is no greater than  $2^{52}$  are representable in the Number type (indeed, the integer 0 has two representations  $+0$  and  $-0$ ).

We say that a finite number has an *odd significand* if it is nonzero and the integer  $m$  used to express it (in one of the two forms shown above) is odd. Otherwise we say that it has an *even significand*.

In this specification, the phrase “the number value for  $x$ ” where  $x$  represents an exact nonzero real mathematical quantity (which might even be an irrational number such as  $\pi$ ) means a number value chosen in the following manner. Consider the set of all finite values of the Number type, with 0 removed and with two additional values added to it that are not representable in the Number type, namely  $2^{1024}$  (which is  $+1 \cdot 2^{53} \cdot 2^{971}$ ) and  $-2^{1024}$  (which is  $-1 \cdot 2^{53} \cdot 2^{971}$ ). Choose the member of this set that is closest in value to  $x$ . If two values of the set are equally close, then the one with an even significand is chosen; for this purpose, the two extra values  $2^{1024}$  and  $-2^{1024}$  are considered to have even significands. Finally, if  $2^{1024}$  was chosen, replace it with  $+\infty$ ; if  $-2^{1024}$  was chosen, replace it with  $-\infty$ ; if  $+0$  was chosen, replace it with  $-0$  if and only if  $x$  is less than zero; any other chosen value is used unchanged. The result is the number value for  $x$ . (This procedure corresponds exactly to the behavior of the IEEE 754 “round to nearest” mode.)

Some ECMAScript operators deal only with integers in the range  $-2^{31}$  through  $2^{31}-1$ , inclusive, or in the range 0 through  $2^{32}-1$ , inclusive. These operators accept any value of the Number type but first convert each such value to one of  $2^{32}$  integer values. See the descriptions of the ToInt32 and ToUint32 operators in sections 9.5 and 9.6, respectively.

## 8.6 THE OBJECT TYPE

An Object is an unordered collection of properties. Each property consists of a name, a value and a set of attributes.

### 8.6.1 Property Attributes

A property can have zero or more attributes from the following set:

Attribute	Description
ReadOnly	The property is a read-only property. Attempts by ECMAScript code to write to the property will be ignored. (Note, however, that in some cases the value of a property with the ReadOnly attribute may change over time because of actions taken by the underlying implementation; therefore “ReadOnly” does not mean “constant and unchanging”!)
DontEnum	The property is not enumerated by a <b>for-in</b> enumeration (section 12.5.3)
DontDelete	Attempts to delete the property will be ignored. See the description of the <b>delete</b> operator in section 1.4.1.
Internal	Internal properties have no name and are not directly accessible via the property accessor operators. How these properties are accessed is implementation specific. How and when some of these properties are used is specified by the language specification.

## 8.6.2 Internal Properties and Methods

Internal properties and methods are not exposed in the language. For the purposes of this document, we give them names enclosed in double square brackets`[[ ]]`. When an algorithm uses an internal property of an object and the object does not implement the indicated internal property, a runtime error is generated.

There are two types of access for exposed properties:`get` and `put`, corresponding to retrieval and assignment.

Native ECMAScript objects have an internal property called `[[Prototype]]`. The value of this property is either `null` or an object and is used for implementing inheritance. Properties of the `[[Prototype]]` object are exposed as properties of the child object for the purposes of get access, but not for put access.

The following table summarizes the internal properties used by this specification. The description indicates their behavior for native ECMAScript objects. Host objects may implement these internal methods with any implement-dependent behavior, or it may be that a host object implements only some internal methods and not others.

Property	Parameters	Description
<code>[[Prototype]]</code>	none	The prototype of this object.
<code>[[Class]]</code>	none	The kind of this object.
<code>[[Value]]</code>	none	Internal state information associated with this object.
<code>[[Get]]</code>	(PropertyName)	Returns the value of the property.
<code>[[Put]]</code>	(PropertyName, Value)	Sets the specified property to Value.
<code>[[CanPut]]</code>	(PropertyName, Value)	Returns a boolean value indicating whether a <code>[[Put]]</code> operation with the same arguments will succeed.
<code>[[HasProperty]]</code>	(PropertyName)	Returns a boolean value indicating whether the object already has a member with the given name.
<code>[[DefaultValue]]</code>	(Hint)	Returns the default value of the object, which should be a primitive value (not an object or reference).
<code>[[Construct]]</code>	optional user-provided parameters	(Constructor) Constructs an object. Invoked via the <code>new</code> operator.
<code>[[Call]]</code>	optional user-provided parameters	(Function) Executes code associated with the object. Invoked via a function call expression.

Every object must implement the `[[Class]]` property and the `[[Get]]`, `[[Put]]`, `[[HasProperty]]`, and `[[DefaultValue]]` methods, even host objects.

The value of the `[[Prototype]]` property must be either an object or `null`, and every `[[Prototype]]` chain must have finite length (that is, starting from any object, recursively accessing the `[[Prototype]]` property must eventually lead to a `null` value).

The value of the `[[Class]]` property is defined by this specification for every kind of built-in object. The value of the `[[Class]]` property of a host object may be any value, even a value used by a built-in object for its `[[Class]]` property. Note that this specification does not provide any means for a program to access the value of a `[[Class]]` property; it is used internally to distinguish different kinds of built-in objects.

Every built-in object implements the `[[Get]]`, `[[Put]]`, `[[CanPut]]`, and `[[HasProperty]]` methods in the manner described in sections 8.6.2.1, 8.6.2.2, and 8.6.2.3, respectively, except that Array objects have a slightly different implementation of the `[[Put]]` method (section ). Host objects may implement these methods in any manner; for example, one possibility is that `[[Get]]` and `[[Put]]` for a particular host object indeed fetch and store property values but `[[HasProperty]]` always generate `false`.

In the following algorithm descriptions, assume `O` is a native ECMAScript object and `P` is a string.

### 8.6.2.1 `[[Get]](P)`

When the `[[Get]]` method of `O` is called with property name `P`, the following steps are taken:

1. If *O* doesn't have a property with name *P*, go to step 4.
2. Get the value of the property.
3. Return Result(2).
4. If the `[[Prototype]]` of *O* is **null**, return **undefined**.
5. Call the `[[Get]]` method of `[[Prototype]]` with property name *P*.
6. Return Result(5).

#### 8.6.2.2 `[[Put]](P, V)`

When the `[[Put]]` method of *O* is called with property *P* and value *V*, the following steps are taken:

1. Call the `[[CanPut]]` method of *O* with name *P*.
2. If Result(1) is false, return.
3. If *O* doesn't have a property with name *P*, go to step 6.
4. Set the value of the property to *V*. The attributes of the property are not changed.
5. Return.
6. Create a property with name *P*, set its value to *V* and give it empty attributes.
7. Return.

Note, however, that if *O* is an Array object, it has a more elaborate `[[Put]]` method (section 5.4.4.1).

#### 8.6.2.3 `[[CanPut]](P)`

The `[[CanPut]]` method is used only by the `[[Put]]` method.

When the `[[CanPut]]` method of *O* is called with property *P*, the following steps are taken:

1. If *O* doesn't have a property with name *P*, go to step 4.
2. If the property has the `ReadOnly` attribute, return **false**.
3. If the `[[Prototype]]` of *O* is **null**, return **true**.
4. Call the `[[CanPut]]` method of `[[Prototype]]` of *O* with property Name *P*.
5. Return Result(4).

#### 8.6.2.4 `[[HasProperty]](P)`

When the `[[HasProperty]]` method of *O* is called with property name *P*, the following steps are taken:

1. If *O* has a property with name *P*, return **true**.
2. If the `[[Prototype]]` of *O* is **null**, return **false**.
3. Call the `[[HasProperty]]` method of `[[Prototype]]` with property name *P*.
4. Return Result(3).

#### 8.6.2.5 `[[DefaultValue]](hint)`

When the `[[DefaultValue]]` method of *O* is called with hint String, the following steps are taken:

1. If *O* does not have a `toString` method, go to step 4.
2. Call the `toString` method of object *O* (with no arguments).
3. If Result(2) is a primitive value, return Result(2).
4. If *O* does not have a `valueOf` method, go to step 7.
5. Call the `valueOf` method of object *O* (with no arguments).
6. If Result(5) is a primitive value, return Result(5).
7. Return *O*.

When the `[[DefaultValue]]` method of *O* is called with hint Number, the following steps are taken:

1. If *O* does not have a `valueOf` method, go to step 4.
2. Call the `valueOf` method of object *O* (with no arguments).
3. If Result(2) is a primitive value, return Result(2).
4. If *O* does not have a `toString` method, go to step 7.
5. Call the `toString` method of object *O* (with no arguments).
6. If Result(5) is a primitive value, return Result(5).
7. Return *O*.

When the `[[DefaultValue]]` method of *O* is called with no hint, then it behaves as if the hint were Number, unless *O* is a Date object (see section 15.9), in which case it behaves as if the hint were String.

## 8.7 THE REFERENCE TYPE

*The internal Reference type is not a language data type.* It is defined by this specification purely for expository purposes. An implementation of ECMAScript must behave as if it produced and operated upon references in the manner described here. However, a value of type **Reference** is used only as an intermediate result of expression evaluation and cannot be stored as the value of a variable or property.

The Reference type is used to explain the behavior of such operators `delete`, `typeof`, and the assignment operators. For example, the left-hand operand of an assignment is expected to produce a reference. The behavior of assignment could, instead, be explained entirely in terms of a case analysis on the syntactic form of the left-hand operand of an assignment operator, but for one difficulty: function calls are permitted to return references. This possibility is admitted purely for the sake of host objects. No built-in ECMAScript function defined by this specification returns a reference and there is no provision for a user-defined function to return a reference.

A **Reference** is a reference to a property of an object. A Reference consists of two parts, the *base object* and the *property name*.

The following abstract operations are used in this specification to describe the behavior of references:

- `GetBase(V)`. Returns the base object component of the reference *V*.
- `GetPropertyname(V)`. Returns the property-name component of the reference *V*.
- `GetValue(V)`. Returns the value of the property indicated by the reference *V*.
- `PutValue(V, W)`. Changes the value of the property indicated by the reference *V* to be *W*.

### 8.7.1 GetBase(V)

1. If `Type(V)` is Reference, return the base object component of *V*.
2. Generate a runtime error.

### 8.7.2 GetPropertyname(V)

1. If `Type(V)` is Reference, return the propertyname component of *V*.
2. Generate a runtime error.

### 8.7.3 GetValue(V)

1. If `Type(V)` is not Reference, return *V*.
2. Call `GetBase(V)`.
3. If `Result(2)` is **null**, generate a runtime error.
4. Call the `[[Get]]` method of `Result(2)`, passing `GetPropertyname(V)` for the propertyname.
5. Return `Result(4)`.

### 8.7.4 PutValue(V, W)

1. If `Type(V)` is not Reference, generate a runtime error.
2. Call `GetBase(V)`.
3. If `Result(2)` is **null**, go to step 6.
4. Call the `[[Put]]` method of `Result(2)`, passing `GetPropertyname(V)` for the property name and *W* for the value.
5. Return.
6. Call the `[[Put]]` method for the global object, passing `GetPropertyname(V)` for the property name and *W* for the value.
7. Return.

## 8.8 THE LIST TYPE

*The internal List type is not a language data type.* It is defined by this specification purely for expository purposes. An implementation of ECMAScript must behave as if it produced and operated

upon List values in the manner described here. However, a value of the List type is used only as an intermediate result of expression evaluation and cannot be stored as the value of a variable or property. The List type is used to explain the evaluation of argument lists (section 1.2.4) in **new** expressions and in function calls. Values of the List type are simply ordered sequences of values. These sequences may be of any length.

## 8.9 THE COMPLETION TYPE

*The internal Completion type is not a language data type.* It is defined by this specification purely for expository purposes. An implementation of ECMAScript must behave as if it produced and operated upon Completion values in the manner described here. However, a value of the Completion type is used only as an intermediate result of statement evaluation and cannot be stored as the value of a variable or property.

The Completion type is used to explain the behavior of statements (**break**, **continue**, and **return**) that perform nonlocal transfers of control. Values of the Completion type have one of the following forms:

- “normal completion”
- “normal completion after value *V*”
- “abrupt completion because of **break**”
- “abrupt completion after value *V* because of **break**”
- “abrupt completion because of **continue**”
- “abrupt completion after value *V* because of **continue**”
- “abrupt completion because of **return** *V*” where *V* is a value

Any completion of one of the four forms that carries a value *V* is called a *value completion*. Any completion of one of the first two forms is called a *normal completion*; any other completion is called an *abrupt completion*. Any completion of a form that mentions **break** is called a **break completion**. Any completion of a form that mentions **continue** is called a **continue completion**. Any completion of a form that mentions **return** is called a **return completion**.

## 9 TYPE CONVERSION

The ECMAScript runtime system performs automatic type conversion as needed. To clarify the semantics of certain constructs it is useful to define a set of conversion operators. These operators are not a part of the language; they are defined here to aid the specification of the semantics of the language. The conversion operators are polymorphic; that is, they can accept a value of any standard type, but not of type Reference.

### 9.1 TOPRIMITIVE

The operator `ToPrimitive` takes a `Value` argument and an optional `PreferredType` argument. The operator `ToPrimitive` attempts to convert its value argument to a non-Object type. If an object is capable of converting to more than one primitive type, it may use the optional hint `PreferredType` to favor that type. Conversion occurs according to the following table:

Input Type	Result
Undefined	The result equals the input argument (no conversion)
Null	The result equals the input argument (no conversion)
Boolean	The result equals the input argument (no conversion)
Number	The result equals the input argument (no conversion)
String	The result equals the input argument (no conversion)
Object	Return the default value of the Object. The default value of an object is retrieved by calling the internal <code>[[DefaultValue]]</code> method of the object, passing the optional hint <code>PreferredType</code> . The behavior of the <code>[[DefaultValue]]</code> method is defined by this specification for all native ECMAScript objects (see section 8.6.2.5). If the return value is of type Object or Reference, a runtime error is generated.

### 9.2 TOBOOLEAN

The operator `ToBoolean` attempts to convert its argument to a value of type Boolean according to the following table:

Input Type	Result
Undefined	<b>false</b>
Null	<b>false</b>
Boolean	The result equals the input argument (no conversion)
Number	The result is <b>false</b> if the argument is <b>+0</b> , <b>-0</b> , or <b>NaN</b> ; otherwise the result is <b>true</b> .
String	The result is <b>false</b> if the argument is the empty string (its length is zero); otherwise the result is <b>true</b> .
Object	<b>true</b>

### 9.3 ToNUMBER

The operator ToNumber attempts to convert its argument to a value of type Number according to the following table:

Input Type	Result
Undefined	<b>NaN</b>
Null	<b>NaN</b>
Boolean	The result is <b>1</b> if the argument is <b>true</b> . The result is <b>+0</b> if the argument is <b>false</b> .
Number	The result equals the input argument (no conversion)
String	See grammar and discussion below.
Object	Apply the following steps: 1. Call ToPrimitive(input argument, hint Number). 2. Call ToNumber(Result(1)). 3. Return Result(2).

#### 9.3.1 ToNumber Applied to the String Type

ToNumber applied to strings applies the following grammar to the input string. If the grammar cannot interpret the string as an expansion of *StringNumericLiteral*, then the result of ToNumber is **NaN**.

*StringNumericLiteral* :::

*StrWhiteSpace<sub>opt</sub> StrNumericLiteral StrWhiteSpace<sub>opt</sub>*

*StrWhiteSpace* :::

*StrWhiteSpaceChar StrWhiteSpace<sub>opt</sub>*

*StrWhiteSpaceChar* :::

<TAB>

<SP>

<FF>

<VT>

<CR>

<LF>

*StrNumericLiteral* :::

*StrDecimalLiteral*

+ *StrDecimalLiteral*

- *StrDecimalLiteral*

*HexIntegerLiteral*

*StrDecimalLiteral* :::

**Infinity**

*DecimalDigits*

*DecimalDigits* . *DecimalDigits<sub>opt</sub> ExponentPart<sub>opt</sub>*

. *DecimalDigits ExponentPart<sub>opt</sub>*

*DecimalDigits ExponentPart*

*DecimalDigits* :::

*DecimalDigit*

*DecimalDigits DecimalDigit*

*DecimalDigit* ::: one of

0 1 2 3 4 5 6 7 8 9

*ExponentPart* :::  
*ExponentIndicator* *SignedInteger*

*ExponentIndicator* ::: one of  
**e E**

*SignedInteger* :::  
*DecimalDigits*  
 + *DecimalDigits*  
 - *DecimalDigits*

*HexIntegerLiteral* :::  
**0x** *HexDigit*  
**0X** *HexDigit*  
*HexIntegerLiteral* *HexDigit*

*HexDigit* ::: one of  
 0 1 2 3 4 5 6 7 8 9 a b c d e f A B C D E F

Some differences should be noted between the syntax of a *StringNumericLiteral* and a *NumericLiteral* (section 7.7.3):

- A *StringNumericLiteral* may be preceded and/or followed by whitespace and/or line terminators.
- A *StringNumericLiteral* may not use octal notation.
- A *StringNumericLiteral* that is decimal may have any number of leading 0 digits.
- A *StringNumericLiteral* that is decimal may be preceded by + or - to indicate its sign.
- A *StringNumericLiteral* that is empty or contains only whitespace and/or one occurrence of + is converted to +0.
- A *StringNumericLiteral* that contains only whitespace and/or one occurrence of - is converted to -0.

The conversion of a string to a number value is similar overall to the determination of the number value for a numeric literal (section 7.7.3), but some of the details are different, so the process for converting a string numeric literal to a value of Number type is given here in full. This value is determined in two steps: first, a mathematical value (MV) is derived from the string numeric literal; second, this mathematical value is rounded, ideally using IEEE 754 round-to-nearest mode, to a representable value of the number type.

- The MV of *StringNumericLiteral* ::: *StrWhiteSpace<sub>opt</sub>* *StrNumericLiteral* *StrWhiteSpace<sub>opt</sub>* is the MV of *StrNumericLiteral*, no matter whether whitespace is present or not.
- The MV of *StrNumericLiteral* ::: *StrDecimalLiteral* is the MV of *StrDecimalLiteral*.
- The MV of *StrNumericLiteral* ::: + *StrDecimalLiteral* is the MV of *StrDecimalLiteral*.
- The MV of *StrNumericLiteral* ::: - *StrDecimalLiteral* is the negative of the MV of *StrDecimalLiteral*.
- The MV of *StrNumericLiteral* ::: *HexIntegerLiteral* is the MV of *HexIntegerLiteral*.
- The MV of *StrDecimalLiteral* ::: **Infinity** is  $10^{10000}$  (a value so large that it will round to  $+\infty$ ).
- The MV of *StrDecimalLiteral* ::: (an empty character sequence) is 0.
- The MV of *StrDecimalLiteral* ::: *DecimalDigits* is the MV of *DecimalDigits*.
- The MV of *StrDecimalLiteral* ::: *DecimalDigits*. is the MV of *DecimalDigits*.
- The MV of *StrDecimalLiteral* ::: *DecimalDigits*. *DecimalDigits* is the MV of the first *DecimalDigits* plus (the MV of the second *DecimalDigits* times  $10^{-n}$ ), where *n* is the number of characters in the second *DecimalDigits*.
- The MV of *StrDecimalLiteral* ::: *DecimalDigits*. *ExponentPart* is the MV of *DecimalDigits* times  $10^e$ , where *e* is the MV of *ExponentPart*.
- The MV of *StrDecimalLiteral* ::: *DecimalDigits*. *DecimalDigits* *ExponentPart* is (the MV of the first *DecimalDigits* plus (the MV of the second *DecimalDigits* times  $10^{-n}$ )) times  $10^e$ , where *n* is the number of characters in the second *DecimalDigits* and *e* is the MV of *ExponentPart*.
- The MV of *StrDecimalLiteral* ::: . *DecimalDigits* is the MV of *DecimalDigits* times  $10^{-n}$ , where *n* is the number of characters in *DecimalDigits*.



- The MV of *StrDecimalLiteral* ::: *DecimalDigits ExponentPart* is the MV of *DecimalDigits* times  $10^{e-n}$ , where  $n$  is the number of characters in *DecimalDigits* and  $e$  is the MV of *ExponentPart*.
- The MV of *StrDecimalLiteral* ::: *DecimalDigits ExponentPart* is the MV of *DecimalDigits* times  $10^e$ , where  $e$  is the MV of *ExponentPart*.
- The MV of *DecimalDigits* ::: *DecimalDigit* is the MV of *DecimalDigit*.
- The MV of *DecimalDigits* ::: *DecimalDigits DecimalDigit* is (the MV of *DecimalDigits* times 10) plus the MV of *DecimalDigit*.
- The MV of *ExponentPart* ::: *ExponentIndicator SignedInteger* is the MV of *SignedInteger*.
- The MV of *SignedInteger* ::: *DecimalDigits* is the MV of *DecimalDigits*.
- The MV of *SignedInteger* ::: + *DecimalDigits* is the MV of *DecimalDigits*.
- The MV of *SignedInteger* ::: - *DecimalDigits* is the negative of the MV of *DecimalDigits*.
- The MV of *DecimalDigit* ::: 0 or of *HexDigit* ::: 0 is 0.
- The MV of *DecimalDigit* ::: 1 or of *HexDigit* ::: 1 is 1.
- The MV of *DecimalDigit* ::: 2 or of *HexDigit* ::: 2 is 2.
- The MV of *DecimalDigit* ::: 3 or of *HexDigit* ::: 3 is 3.
- The MV of *DecimalDigit* ::: 4 or of *HexDigit* ::: 4 is 4.
- The MV of *DecimalDigit* ::: 5 or of *HexDigit* ::: 5 is 5.
- The MV of *DecimalDigit* ::: 6 or of *HexDigit* ::: 6 is 6.
- The MV of *DecimalDigit* ::: 7 or of *HexDigit* ::: 7 is 7.
- The MV of *DecimalDigit* ::: 8 or of *HexDigit* ::: 8 is 8.
- The MV of *DecimalDigit* ::: 9 or of *HexDigit* ::: 9 is 9.
- The MV of *HexDigit* ::: a or of *HexDigit* ::: A is 10.
- The MV of *HexDigit* ::: b or of *HexDigit* ::: B is 11.
- The MV of *HexDigit* ::: c or of *HexDigit* ::: C is 12.
- The MV of *HexDigit* ::: d or of *HexDigit* ::: D is 13.
- The MV of *HexDigit* ::: e or of *HexDigit* ::: E is 14.
- The MV of *HexDigit* ::: f or of *HexDigit* ::: F is 15.
- The MV of *HexIntegerLiteral* ::: 0x *HexDigit* is the MV of *HexDigit*.
- The MV of *HexIntegerLiteral* ::: 0X *HexDigit* is the MV of *HexDigit*.
- The MV of *HexIntegerLiteral* ::: *HexIntegerLiteral HexDigit* is (the MV of *HexIntegerLiteral* times 16) plus the MV of *HexDigit*.

Once the exact MV for a string numeric literal has been determined, it is then rounded to a value of the Number type. If the MV is 0, then the rounded value is **+0** unless the first non-whitespace character in the string numeric literal is '-', in which case the rounded value is **-0**. Otherwise, the rounded value must be *the* number value for the MV (in the sense defined in section 8.4), unless the literal includes a *StrDecimalLiteral* and the literal has more than 20 significant digits, in which case the number value may be any implementation-dependent approximation to the MV. A digit is *significant* if it is not part of an *ExponentPart* and (either it is not 0 or it is an *important zero* or there is no decimal point '.' in the literal). A digit 0 is an *important zero* if there is at least one important item to its left and at least one *important item* to its right within the literal. Any digit that is not 0 and is not part of an *ExponentPart* is an important item; a decimal point '.' is also an important item.

## 9.4 ToInteger

The operator ToInteger attempts to convert its argument to an integral numeric value. This operator functions as follows:

1. Call ToNumber on the input argument.
2. If Result(1) is NaN, return +0.
3. If Result(1) is +0, -0, +∞, or -∞, return Result(1).
4. Compute sign(Result(1)) \* floor(abs(Result(1))).
5. Return Result(4).

## 9.5 ToInt32: (SIGNED 32 BIT INTEGER)

The operator ToInt32 converts its argument to one of  $2^{32}$  integer values in the range  $-2^{31}$  through  $2^{31}-1$ , inclusive. This operator functions as follows:

1. Call ToNumber on the input argument.
2. If Result(1) is NaN, +0, -0, +∞, or -∞, return +0.
3. Compute  $\text{sign}(\text{Result}(1)) * \text{floor}(\text{abs}(\text{Result}(1)))$ .
4. Compute Result(3) modulo  $2^{32}$ ; that is, a finite integer value  $k$  of Number type with positive sign and less than  $2^{32}$  in magnitude such the mathematical difference of Result(3) and  $k$  is mathematically an integer multiple of  $2^{32}$ .
5. If Result(4) is greater than or equal to  $2^{31}$ , return  $\text{Result}(4) - 2^{32}$ ; otherwise return Result(4).

### Discussion:

Note that the ToInt32 operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.

Note also that  $\text{ToInt32}(\text{ToUint32}(x))$  is equal to  $\text{ToInt32}(x)$  for all values of  $x$ .

(It is to preserve this latter property that +∞ and -∞ are mapped to +0.)

Note that ToInt32 maps -0 to +0.

## 9.6 ToUint32: (UNSIGNED 32 BIT INTEGER)

The operator ToUint32 converts its argument to one of  $2^{32}$  integer values in the range 0 through  $2^{32}-1$ , inclusive. This operator functions as follows:

1. Call ToNumber on the input argument.
2. If Result(1) is NaN, +0, -0, +∞, or -∞, return +0.
3. Compute  $\text{sign}(\text{Result}(1)) * \text{floor}(\text{abs}(\text{Result}(1)))$ .
4. Compute Result(3) modulo  $2^{32}$ ; that is, a finite integer value  $k$  of Number type with positive sign and less than  $2^{32}$  in magnitude such the mathematical difference of Result(3) and  $k$  is mathematically an integer multiple of  $2^{32}$ .
5. Return Result(4).

### Discussion:

Note that step 6 is the only difference between ToUint32 and ToInt32.

Note that the ToUint32 operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.

Note also that  $\text{ToUint32}(\text{ToInt32}(x))$  is equal to  $\text{ToUint32}(x)$  for all values of  $x$ .

(It is to preserve this latter property that +∞ and -∞ are mapped to +0.)

Note that ToUint32 maps -0 to +0.

## 9.7 ToUint16: (UNSIGNED 16 BIT INTEGER)

The operator ToUint16 converts its argument to one of  $2^{16}$  integer values in the range 0 through  $2^{16}-1$ , inclusive. This operator functions as follows:

1. Call ToNumber on the input argument.
2. If Result(1) is NaN, +0, -0, +∞, or -∞, return +0.
3. Compute  $\text{sign}(\text{Result}(1)) * \text{floor}(\text{abs}(\text{Result}(1)))$ .
4. Compute Result(3) modulo  $2^{16}$ ; that is, a finite integer value  $k$  of Number type with positive sign and less than  $2^{16}$  in magnitude such the mathematical difference of Result(3) and  $k$  is mathematically an integer multiple of  $2^{16}$ .
5. Return Result(4).

### Discussion:

Note that the substitution of  $2^{16}$  for  $2^{32}$  in step 4 is the only difference between ToUint32 and ToUnit16.

Note that ToUint16 maps -0 to +0.

## 9.8 ToString

The operator ToString attempts to convert its argument to a value of type String according to the following table:

Input Type	Result
Undefined	"undefined"
Null	"null"
Boolean	<b>true</b> → "true" <b>false</b> → "false"
Number	See discussion below.
String	Return the input argument (no conversion)
Object	Apply the following steps: 1. Call ToPrimitive(input argument, hint String). 2. Call ToString(Result(1)). 3. Return Result(2).

### 9.8.1 ToString Applied to the Number Type

The operator ToString converts a number to string format as follows:

- If the argument is NaN, the result is the string "NaN".
- If the argument is +0 or -0, the result is "0".
- If the argument is +∞, the result is "Infinity".
- If the argument is -∞, the result is "-Infinity".
- Otherwise, the result is a string that represents the sign and finite nonzero magnitude (absolute value) of the argument. If the sign is negative, the first character of the result is '-'; if the sign is positive, no sign character appears in the result. As for the magnitude  $m$ :
  - If  $m$  is an integer less than  $10^{21}$ , then it is represented as that integer value in decimal form with no leading zeroes and no decimal point.
  - If  $m$  is greater than or equal to  $10^6$  but less than  $10^{21}$ , and is not an exact integer value, then it is represented as the integer part (floor) of  $m$ , in decimal form with no leading zeroes, followed by a decimal point '.', followed by one or more decimal digits (see below) representing the fractional part of  $m$ .
  - If  $m$  is less than  $10^6$  or not less than  $10^{21}$ , then it is represented in so-called "computerized scientific notation." Let  $n$ ,  $k$ , and  $a$  be integers such that  $k \geq 1$ ,  $10^k \leq a < 10^{k+1}$ , the number value for  $a \cdot 10^{n-k}$  is  $m$ , and  $k$  is as small as possible. The magnitude is then represented as the integer part (floor) of  $a \cdot 10^{-k}$ , as a single decimal digit, followed by a decimal point '.', followed by one or more decimal digits (see below) representing the fractional part of  $a \cdot 10^{-k}$ , followed by the lowercase letter 'e', followed by a representation of  $n$  as a decimal integer (first a minus sign '-' if  $n$  is negative or a plus sign '+' if  $n$  is not negative, followed by the decimal representation of the magnitude of  $n$  with no leading zeros).

How many digits must be printed for the fractional part of  $m$  or  $a \cdot 10^{-k}$ ? There must be at least one digit; beyond that, there must be as many, but only as many, more digits as are needed to uniquely distinguish the argument value from all other representable numeric values. That is, suppose that is the exact mathematical value represented by the decimal representation produced by this method for a finite nonzero argument; then  $d$  must be the value of Number type nearest to  $x$ ; or if two values of the Number type are equally close to  $x$ , then  $d$  must be one of them and the least significant bit of  $d$  must be 0. A consequence of this specification is that ToString never produces trailing zero digits for a fractional part.

There remains some choice as to the last digit generated for a fractional part. The following specification was considered but not adopted:

*(This paragraph is not part of the ECMAScript specification)* The decimal string produced must be as close in its mathematical value to the mathematical value of the original number as any other decimal string with the same number of digits; and if two decimal strings of the same minimal length would be equally close in value to the original number, then the decimal string whose last digit is even should be chosen.

While such a strategy is recommended to implementors, the actual rule is somewhat more permissive (and is implied by the rules above):

If  $x$  is any number value, then `ToNumber(ToString(x))` must be exactly the same as  $x$ .

Implementors of ECMAScript may find useful the paper and code written by David M. Gay for binary-to-decimal conversion of floating-point numbers [Gay 1990].

## 9.9 ToOBJECT

The operator `ToObject` attempts to convert its argument to a value of type `Object` according to the following table:

<b>Input Type</b>	<b>Result</b>
Undefined	Generate a runtime error.
Null	Generate a runtime error.
Boolean	Create a new Boolean object whose default value is the value of the boolean. See section 15.6 for a description of Boolean objects.
Number	Create a new Number object whose default value is the value of the number. See section 15.7 for a description of Number objects.
String	Create a new String object whose default value is the value of the string. See section 15.5 for a description of String objects.
Object	The result is the input argument (no conversion)

# 10 EXECUTION CONTEXTS

When control is transferred to ECMAScript executable code, we say that control is entering an *execution context*. Active execution contexts logically form a stack. The top execution context on this logical stack is the running execution context.

## 10.1 DEFINITIONS

### 10.1.1 Function Objects

There are four types of function objects:

- Declared functions are defined in source text by a *FunctionDeclaration*.
- Anonymous functions are created dynamically by using the built-in **Function** object as a constructor, which we refer to as *instantiatingFunction*.
- Host functions are created at the request of the host with source text supplied by the host. The mechanism for their creation is implementation dependent. Host functions may have any subset of the following attributes { *ImplicitThis*, *ImplicitParents* } Note that these are attributes of function objects, not of properties. These attributes are described below.
- Internal functions are built-in objects of the language, such as **parseInt** and **Math.exp**. An implementation may also provide implementation-dependent internal functions that are not described in this specification. These functions do not contain executable code defined by the ECMAScript grammar, so are excluded from this discussion of execution contexts.

### 10.1.2 Types of Executable Code

There are five types of executable ECMAScript source text:

- *Global code* is source text that is outside all function declarations. More precisely, the global code of a particular *ECMAScriptProgram* consists of all *SourceElements* in the *Program* production which come from the *Statement* definition.
- *Eval code* is the source text supplied to the built-in **eval** function. More precisely, if the parameter to the built-in **eval** function is a string, it is treated as an *ECMAScriptProgram*. The eval code for a particular invocation of **eval** is the global code portion of the string parameter.
- *Function code* is source text that is inside a function declaration. More precisely, the function code of a particular *ECMAScriptFunctionDeclaration* consists of the *Block* in the definition of *FunctionDeclaration*.
- *Anonymous code* is the source text supplied when *instantiatingFunction*. More precisely, the last parameter provided in an instantiation of **Function** is converted to a string and treated as the *StatementList* of the *Block* of a *FunctionDeclaration*. If more than one parameter is provided in an instantiation of **Function**, all parameters except the last one are converted to strings and concatenated together, separated by commas. The resulting string is interpreted as the *FormalParameterList* of a *FunctionDeclaration* for the *StatementList* defined by the last parameter.
- *Host code* is the source text supplied by the host when creating a host function. The source text is treated as the *StatementList* of the *Block* of a *FunctionDeclaration*. Depending on the implementation, the host may also supply a *FormalParameterList*.

### 10.1.3 Variable Instantiation

Every execution context has associated with it a *variable object*. Variables declared in the source text are

added as properties of the variable object. For global and eval code, functions defined in the source text are added as properties of the variable object. Function declarations in other types of code are not allowed by the grammar. For function, anonymous and host code, parameters are added as properties of the variable object.

Which object is used as the variable object and what attributes are used for the properties depends on the

type of code, but the remainder of the behavior is generic:

- For each *FunctionDeclaration* in the code, in source text order, instantiate a declared function from the *FunctionDeclaration* and create a property of the variable object whose name is the *Identifier* in the *FunctionDeclaration*, whose value is the declared function and whose attributes are determined by the type of code. If the variable object already has a property with this name, replace its value and attributes.
- For each formal parameter, as defined in the *FormalParameterList*, create a property of the variable object whose name is the *Identifier* and whose attributes are determined by the type of code. The values of the parameters are supplied by the caller. If the caller supplies fewer parameter values than there are formal parameters, the extra formal parameters have value **undefined**. If two or more formal parameters share the same name, hence the same property, the corresponding property is given the value that was supplied for the last parameter with this name. If the value of this last parameter was not supplied by the caller, the value of the corresponding property is **undefined**.
- For each *VariableDeclaration* in the code, create a property of the variable object whose name is the *Identifier* in *VariableDeclaration*, whose value is **undefined** and whose attributes are determined by the type of code. If there is already a property of the variable object with the name of a declared variable, the value of the property and its attributes are not changed. Semantically, this step must follow the creation of the *FunctionDeclaration* and *FormalParameterList* properties. In particular, if a declared variable has the same name as a declared function or formal parameter, the variable declaration does not disturb the existing property.

### 10.1.4 Scope Chain and Identifier Resolution

Every execution context has associated with it a *scope chain*. This is logically a list of objects that are searched when *binding* an *Identifier*. When control enters an execution context, the scope chain is created and is populated with an initial set of objects, depending on the type of code. When control leaves the execution context, the scope chain is destroyed.

During execution, the scope chain of the execution context is affected only by *WithStatement*. When execution enters a **with** block, the object specified in the **with** statement is added to the front of the scope chain. When execution leaves a **with** block, whether normally or via **break** or **continue** statement, the object is removed from the scope chain. The object being removed will always be the first object in the scope chain.

During execution, the syntactic production *PrimaryExpression: Identifier* is evaluated using the following algorithm:

1. Get the next object in the scope chain. If there isn't one, go to step 5.
2. Call the `[[HasProperty]]` method of `Result(1)`, passing the *identifier* as the property.
3. If `Result(2)` is **true**, return a value of type `Reference` whose base object is `Result(1)` and whose property name is the *Identifier*.
4. Go to step 1.
5. Return a value of type `Reference` whose base object is **null** and whose property name is the *Identifier*.

The result of binding an identifier is always a value of type `Reference` with its member name component equal to the identifier string.

### 10.1.5 Global Object

There is a unique *global object* which is created before control enters any execution context. Initially the global object has the following properties:

- Built-in objects such as Math, String, Date, parseInt, etc. These have attributes { DontEnum }.
- Additional host defined properties. This may include a property whose value is the global object itself, for example `window` in HTML.

As control enters execution contexts, and as ECMAScript code is executed, additional properties may be added to the global object and the initial properties may be changed.

### 10.1.6 Activation Object

When control enters an execution context for declared function code, anonymous code or host code, an object called the activation object is created and associated with the execution context. The activation object is initialized with a property with name `arguments` and property attributes { DontDelete }. The initial value of this property is the arguments object described below.

If the function object being invoked has an `arguments` property, let  $x$  be the value of that property; the activation object is also given an internal property `[[OldArguments]]` whose initial value is  $x$ ; otherwise, an `arguments` property is created for the function object but the activation object is not given an `[[OldArguments]]` property. Next, arguments object described below (the same one stored in the `arguments` property of the activation object) is used as the new value of the `arguments` property of the function object. This new value is installed even if the `arguments` property already exists and has the `ReadOnly` attribute. (These actions are taken to provide compatibility with a form of program syntax that is now discouraged: to access the arguments object for function `f` within the body of `f` by using the expression `f.arguments`. The recommended way to access the arguments object for function `f` within the body of `f` is simply to refer to the variable `arguments`.)

The activation object is then used as the variable object for the purposes of variable instantiation.

When a value is to be returned from the call to a function, its activation object is no longer needed and may be permanently decommissioned. At this time, if the activation object has no `[[OldArguments]]` property, then the `arguments` property of the function object is deleted; otherwise, the value of the `[[OldArguments]]` property of the activation object is stored into the `arguments` property of the function object (an `arguments` property is created for the function object if necessary). This old value is stored even if the `arguments` property already exists and has the `ReadOnly` attribute.

The activation object is purely a specification mechanism. It is impossible for an ECMAScript program to access the activation object. It can access members of the activation object, but not the activation object itself. When the call operation is applied to a Reference value whose base object is an activation object, `null` is used as the `this` value of the call.

### 10.1.7 This

There is a `this` value associated with every active execution context. The `this` value depends on the caller and the type of code being executed and is determined when control enters the execution context. The `this` value associated with an execution context is immutable.

### 10.1.8 Arguments Object

When control enters an execution context for declared function code, anonymous code, or host code, an arguments object is created and initialized as follows:

- A property is created with name `callee` and property attributes { DontEnum }. The initial value of this property is the function object being executed. This allows anonymous functions to be recursive.
- A property is created with name `length` and property attributes { DontEnum }. The initial value of this property is the number of actual parameter values supplied by the caller.
- For each non-negative integer,  $iarg$ , less than the value of the `length` property, a property is created with name `Tostring( $iarg$ )` and property attributes { DontEnum }. The initial value of this property is the value of the corresponding actual parameter supplied by the caller. The first actual parameter value corresponds to  $iarg = 0$ , the second to  $iarg = 1$  and so on. In the case when  $iarg$  is

less than the number of formal parameters for the function object, this property shares its value with the corresponding property of the activation object. This means that changing this property changes the corresponding property of the activation object and vice versa. The value sharing mechanism depends on the implementation.

## 10.2 ENTERING AN EXECUTION CONTEXT

When control enters an execution context, the scope chain is created and initialized, variable instantiation is performed, and the `this` value is determined.

The initialization of the scope chain, variable instantiation, and the determination of the `this` value depend on the type of code being entered.

### 10.2.1 Global Code

- The scope chain is created and initialized to contain the global object and no others.
- Variable instantiation is performed using the global object as the variable object and using empty property attributes.
- The `this` value is the global object.

### 10.2.2 EvalCode

When control enters an execution context for eval code, the previous active execution context, referred to as the *calling context*, is used to determine the scope chain, the variable object, and the `this` value. If there is no calling context, then initializing the scope chain, variable instantiation, and determination of the `this` value are performed just as for global code.

- The scope chain is initialized to contain the same objects, in the same order, as the calling context's scope chain. This includes objects added to the calling context's scope chain by *WithStatement*.
- Variable instantiation is performed using the calling context's variable object and using empty property attributes.
- The `this` value is the same as the `this` value of the calling context.

### 10.2.3 Function and Anonymous Code

- The scope chain is initialized to contain the activation object followed by the global object.
- Variable instantiation is performed using the activation object as the variable object and using property attributes { DontDelete }.
- The caller provides the `this` value. If the `this` value provided by the caller is not an object (including the case where it is `null`), then the `this` value is the global object.

### 10.2.4 Host Code

- The scope chain is initialized to contain the activation object as its first element.
- If the host function has the `ImplicitThis` attribute, the `this` value is placed in the scope chain after the activation object.
- If the host function has the `ImplicitParents` attribute, a list of objects determined solely by the `this` value, is inserted in the scope chain after the activation object and `this` object. Note that this list is determined at runtime by the `this` value. It is not determined by any form of lexical scoping.
- The global object is placed in the scope chain after all other objects.
- Variable instantiation is performed using the activation object as the variable object and using attributes { DontDelete }.
- The `this` value is determined just as for function and anonymous code.



# 11 EXPRESSIONS

## 11.1 PRIMARY EXPRESSIONS

### Syntax

*PrimaryExpression* :  
    *this*  
    *Identifier*  
    *Literal*  
    ( *Expression* )

### 11.1.1 The `this` Keyword

The `this` keyword evaluates to the `this` value of the execution context.

### 11.1.2 Identifier Reference

An *Identifier* is evaluated using the scoping rules stated in section Scope Chain and Identifier Resolution. The result of an *Identifier* is always a value of type Reference.

### 11.1.3 Literal Reference

A *Literal* is evaluated as described in section Literals.

### 11.1.4 The Grouping Operator

The production *PrimaryExpression* : ( *Expression* ) is evaluated as follows:

1. Evaluate *Expression*. This may be of type Reference.
2. Return Result(1).

## 11.2 LEFT-HAND-SIDE EXPRESSIONS

### Syntax

*MemberExpression* :  
    *PrimaryExpression*  
    *MemberExpression* [ *Expression* ]  
    *MemberExpression* . *Identifier*  
    **new** *MemberExpression* [no *LineTerminator* here] *Arguments*

*NewExpression* :  
    *MemberExpression*  
    **new** *NewExpression*

*CallExpression* :  
    *MemberExpression* [no *LineTerminator* here] *Arguments*  
    *CallExpression* [no *LineTerminator* here] *Arguments*  
    *CallExpression* [ *Expression* ]  
    *CallExpression* . *Identifier*

*Arguments :*  
( )  
( *ArgumentList* )

*ArgumentList :*  
*AssignmentExpression*  
*ArgumentList* , *AssignmentExpression*

*LeftHandSideExpression :*  
*NewExpression*  
*CallExpression*

### 11.2.1 Property Accessors

Properties are accessed by name, using either the dot notation

*MemberExpression* . *Identifier*  
*CallExpression* . *Identifier*

or the bracket notation

*MemberExpression* [ *Expression* ]  
*CallExpression* [ *Expression* ]

The dot notation is explained by the following syntactic conversion:

*MemberExpression* . *Identifier*

is identical in its behavior to

*MemberExpression* [ <identifier-string> ]

and similarly

*CallExpression* . *Identifier*

is identical in its behavior to

*CallExpression* [ <identifier-string> ]

where <identifier-string> is a string literal containing the same sequence of characters as the *Identifier*.

The production *MemberExpression* : *MemberExpression* [ *Expression* ] is evaluated as follows:

1. Evaluate *MemberExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *Expression*.
4. Call GetValue(Result(3)).
5. Call ToObject(Result(2)).
6. Call ToString(Result(4)).
7. Return a value of type Reference whose base object is Result(5) and whose property name is Result(6).

The production *CallExpression* : *CallExpression* [ *Expression* ] is evaluated in exactly the same manner, except that the contained *CallExpression* is evaluated in step 1.

### 11.2.2 The new Operator

The production *NewExpression* : **new** *NewExpression* is evaluated as follows:

1. Evaluate *NewExpression*.
2. Call GetValue(Result(1)).
3. If Type(Result(2)) is not Object, generate a runtime error.
4. If Result(2) does not implement the internal [[Construct]] method, generate a runtime error.
5. Call the [[Construct]] method on Result(2), providing no arguments (that is, an empty list of arguments).
6. If Type(Result(5)) is not Object, generate a runtime error.
7. Return Result(5).

The production *NewCallExpression*: **new** *NewExpression Arguments* is evaluated as follows:

1. Evaluate *NewExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *Arguments*, producing an internal list of argument values (section 1.2.4).
4. If Type(Result(2)) is not Object, generate a runtime error.
5. If Result(2) does not implement the internal [[Construct]] method, generate a runtime error.
6. Call the [[Construct]] method on Result(2), providing the list Result(3) as the argument values.
7. If Type(Result(6)) is not Object, generate a runtime error.
8. Return Result(6).

### 11.2.3 Function Calls

The production *CallExpression*: *MemberExpression Arguments* is evaluated as follows:

1. Evaluate *MemberExpression*.
2. Evaluate *Arguments*, producing an internal list of argument values (section 1.2.4).
3. Call GetValue(Result(1)).
4. If Type(Result(3)) is not Object, generate a runtime error.
5. If Result(3) does not implement the internal [[Call]] method, generate a runtime error.
6. If Type(Result(1)) is Reference, Result(6) is GetBase(Result(1)). Otherwise Result(6) is **null**.
7. If Result(6) is an activation object, Result(7) is **null**. Otherwise, Result(7) is the same as Result(6).
8. Call the [[Call]] method on Result(3), providing Result(7) as the **this** value and providing the list Result(2) as the argument values.
9. Return Result(8).

The production *CallExpression*: *CallExpression Arguments* is evaluated in exactly the same manner except that the contained *CallExpression* is evaluated in step 1.

**Note:** Result(8) will never be of type Reference if Result(3) is a native ECMAScript object. Whether calling a host object can return a value of type Reference is implementation dependent.

### 11.2.4 Argument Lists

The evaluation of an argument list produces an internal list of values (section 8.8).

The production *Arguments*: ( ) is evaluated as follows:

1. Return an empty internal list of values.

The production *Arguments*: ( *ArgumentList* ) is evaluated as follows:

1. Evaluate *ArgumentList*.
2. Return Result(1).

The production *ArgumentList*: *AssignmentExpression* is evaluated as follows:

1. Evaluate *AssignmentExpression*.
2. Call GetValue(Result(1)).
3. Return an internal list whose sole item is Result(2).

The production *ArgumentList*: *ArgumentList* , *AssignmentExpression* is evaluated as follows:

1. Evaluate *ArgumentList*.
2. Evaluate *AssignmentExpression*.
3. Call GetValue(Result(2)).
4. Return an internal list whose length is one greater than the length of Result(1) and whose items are the items of Result(1), in order, followed at the end by Result(3), which is the last item of the new list.

## 11.3 POSTFIX EXPRESSIONS

### Syntax

*PostfixExpression*:

*LeftHandSideExpression*

*LeftHandSideExpression* [no *LineTerminator* here] ++

*LeftHandSideExpression* [no *LineTerminator* here] --

### 11.3.1 Postfix Increment Operator

The production *MemberExpression*: *MemberExpression*++ is evaluated as follows:

1. Evaluate *MemberExpression*.
2. Call GetValue(Result(1)).
3. Call ToNumber(Result(2)).
4. Add the value 1 to Result(3), using the same rules as for the+ operator (section 11.6.3).
5. Call PutValue(Result(1), Result(4)).
6. Return Result(3).

### 11.3.2 Postfix Decrement Operator

The production *MemberExpression*: *MemberExpression*-- is evaluated as follows:

1. Evaluate *MemberExpression*.
2. Call GetValue(Result(1)).
3. Call ToNumber(Result(2)).
4. Subtract the value 1 from Result(3), using the same rules as for the- operator (section 11.6.3).
5. Call PutValue(Result(1), Result(4)).
6. Return Result(3).

## 11.4 UNARY OPERATORS

### Syntax

*UnaryExpression*:

*PostfixExpression*

**delete** *UnaryExpression*

**void** *UnaryExpression*

**typeof** *UnaryExpression*

**++** *UnaryExpression*

**--** *UnaryExpression*

**+** *UnaryExpression*

**-** *UnaryExpression*

**~** *UnaryExpression*

**!** *UnaryExpression*

### 11.4.1 The delete Operator

The production *UnaryExpression*: **delete** *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call GetBase(Result(1)).
3. Call GetPropertyName(Result(1)).
4. If Type(Result(2)) is not Object, return **true**.
5. If Result(2) does not implement the internal [[Delete]] method go to step 8.
6. Call the [[Delete]] method on Result(2), providing Result(3) as the property name to delete.
7. Return Result(6).
8. Call the [[HasProperty]] method on Result(2), providing Result(3) as the property name to check for.
9. If Result(8) is **true**, return **false**.
10. Return **true**.

### 11.4.2 The `void` Operator

The production *UnaryExpression*: **void** *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call `GetValue(Result(1))`.
3. Return undefined.

### 11.4.3 The `typeof` Operator

The production *UnaryExpression*: **typeof** *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. If `Type(Result(1))` is Reference and `GetBase(Result(1))` is **null**, return **"undefined"**.
3. Call `GetValue(Result(1))`.
4. Return a string determined by `Type(Result(3))` according to the following table:

Type	Result
Undefined	<b>"undefined"</b>
Null	<b>"object"</b>
Boolean	<b>"boolean"</b>
Number	<b>"number"</b>
String	<b>"string"</b>
Object (native and doesn't implement <code>[[Call]]</code> )	<b>"object"</b>
Object (native and implements <code>[[Call]]</code> )	<b>"function"</b>
Object (host)	Implementation-dependent

### 11.4.4 Prefix Increment Operator

The production *UnaryExpression*: **++** *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call `GetValue(Result(1))`.
3. Call `ToNumber(Result(2))`.
4. Add the value **1** to `Result(3)`, using the same rules as for the `+` operator (section 11.6.3).
5. Call `PutValue(Result(1), Result(4))`.
6. Return `Result(4)`.

### 11.4.5 Prefix Decrement Operator

The production *UnaryExpression*: **--** *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call `GetValue(Result(1))`.
3. Call `ToNumber(Result(2))`.
4. Subtract the value **1** from `Result(3)`, using the same rules as for the `-` operator (section 11.6.3).
5. Call `PutValue(Result(1), Result(4))`.
6. Return `Result(4)`.

### 11.4.6 Unary `+` Operator

The unary `+` operator converts its operand to Number type.

The production *UnaryExpression*: **+** *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call `GetValue(Result(1))`.
3. Call `ToNumber(Result(2))`.

4. Return Result(3).

### 11.4.7 Unary - Operator

The unary - operator converts its operand to Number type and then negates it. Note that negating 0 produces -0, and negating -0 produces +0.

The production *UnaryExpression* : - *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call GetValue(Result(1)).
3. Call ToNumber(Result(2)).
4. If Result(3) is NaN, return NaN.
5. Negate Result(3); that is, compute a number with the same magnitude but opposite sign
6. Return Result(5).

### 11.4.8 The Bitwise NOT Operator (~ )

The production *UnaryExpression* : ~ *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call GetValue(Result(1)).
3. Call ToInt32(Result(2)).
4. Apply bitwise complement to Result(3). The result is a signed 32-bit integer.
5. Return Result(4).

### 11.4.9 Logical NOT Operator (! )

The production *UnaryExpression* : ! *UnaryExpression* is evaluated as follows:

1. Evaluate *UnaryExpression*.
2. Call GetValue(Result(1)).
3. Call ToBoolean(Result(2)).
4. If Result(3) is true, return false.
5. Return true.

## 11.5 MULTIPLICATIVE OPERATORS

### Syntax

*MultiplicativeExpression* :  
*UnaryExpression*  
*MultiplicativeExpression* \* *UnaryExpression*  
*MultiplicativeExpression* / *UnaryExpression*  
*MultiplicativeExpression* % *UnaryExpression*

### Semantics

The production *MultiplicativeExpression* : *MultiplicativeExpression* @ *UnaryExpression*, where @ stands for one of the operators in the above definitions, is evaluated as follows:

1. Evaluate *MultiplicativeExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *UnaryExpression*.
4. Call GetValue(Result(3)).
5. Call ToNumber(Result(2)).
6. Call ToNumber(Result(4)).
7. Apply the specified operation (\*, /, or %) to Result(5) and Result(6). See the discussions below (7.4.1, 7.4.2, 7.4.3).
8. Return Result(7).

### 11.5.1 Applying the \* Operator

The \* operator performs multiplication, producing the product of its operands. Multiplication is commutative. Multiplication is not always associative in ECMAScript, because of finite precision. The result of a floating-point multiplication is governed by the rules of IEEE 754 double-precision arithmetic:

- If either operand is NaN, the result is NaN.
- The sign of the result is positive if both operands have the same sign, negative if the operands have different signs.
- Multiplication of an infinity by a zero results in NaN.
- Multiplication of an infinity by an infinity results in an infinity. The sign is determined by the rule already stated above.
- Multiplication of an infinity by a finite non-zero value results in a signed infinity. The sign is determined by the rule already stated above.
- In the remaining cases, where neither an infinity or NaN is involved, the product is computed and rounded to the nearest representable value using IEEE 754 round-to-nearest mode. If the magnitude is too large to represent, the result is then an infinity of appropriate sign. If the magnitude is too small to represent, the result is then a zero of appropriate sign. The ECMAScript language requires support of gradual underflow as defined by IEEE 754.

### 11.5.2 Applying the / Operator

The / operator performs division, producing the quotient of its operands. The left operand is the dividend and the right operand is the divisor. ECMAScript does not perform integer division. The operands and result of all division operations are double-precision floating-point numbers. The result of division is determined by the specification of IEEE 754 arithmetic:

- If either operand is NaN, the result is NaN.
- The sign of the result is positive if both operands have the same sign, negative if the operands have different signs.
- Division of an infinity by an infinity results in NaN.
- Division of an infinity by a zero results in an infinity. The sign is determined by the rule already stated above.
- Division of an infinity by a non-zero finite value results in a signed infinity. The sign is determined by the rule already stated above.
- Division of a finite value by an infinity results in zero. The sign is determined by the rule already stated above.
- Division of a zero by a zero results in NaN; division of zero by any other finite value results in zero with the sign determined by the rule already stated above..
- Division of a non-zero finite value by a zero results in a signed infinity. The sign is determined by the rule already stated above.
- In the remaining cases, where neither an infinity, nor a zero, nor NaN is involved, the quotient is computed and rounded to the nearest representable value using IEEE 754 round-to-nearest mode. If the magnitude is too large to represent, we say the operation overflows; the result is then an infinity of appropriate sign. If the magnitude is too small to represent, we say the operation underflows and the result is a zero of the appropriate sign. The ECMAScript language requires support of gradual underflow as defined by IEEE 754.

### 11.5.3 Applying the % Operator

The binary % operator is said to yield the remainder of its operands from an implied division; the left operand is the dividend and the right operand is the divisor. In C and C++, the remainder operator accepts only integral operands, but in ECMAScript, it also accepts floating-point operands.

The result of a floating-point remainder operation as computed by the % operator is not the same as the "remainder" operation defined by IEEE 754. The IEEE 754 "remainder" operation computes the

remainder from a rounding division, not a truncating division, and so its behavior is not analogous to that of the usual integer remainder operator. Instead the ECMAScript language defines `%` on floating-point operations to behave in a manner analogous to that of the Java integer remainder operator; this may be compared with the C library function `fmod`.

The result of a ECMAScript floating-point remainder operation is determined by the rules of IEEE arithmetic:

- If either operand is NaN, the result is NaN.
- The sign of the result equals the sign of the dividend.
- If the dividend is an infinity, or the divisor is a zero, or both, the result is NaN.
- If the dividend is finite and the divisor is an infinity, the result equals the dividend.
- If the dividend is a zero and the divisor is finite, the result is the same as the dividend
- In the remaining cases, where neither an infinity, nor a zero, nor NaN is involved, the floating-point remainder  $r$  from a dividend  $n$  and a divisor  $d$  is defined by the mathematical relation  $r = n - (d * q)$  where  $q$  is an integer that is negative only if  $n/d$  is negative and positive only if  $n/d$  is positive, and whose magnitude is as large as possible without exceeding the magnitude of the true mathematical quotient of  $n$  and  $d$ .

## 11.6 ADDITIVE OPERATORS

### Syntax

*AdditiveExpression* :  
    *MultiplicativeExpression*  
    *AdditiveExpression* + *MultiplicativeExpression*  
    *AdditiveExpression* - *MultiplicativeExpression*

### 11.6.1 The Addition Operator (+ )

The addition operator either performs string concatenation or numeric addition.

The production *AdditiveExpression* : *AdditiveExpression* + *MultiplicativeExpression* is evaluated as follows:

1. Evaluate *AdditiveExpression*.
2. Call `GetValue(Result(1))`.
3. Evaluate *MultiplicativeExpression*.
4. Call `GetValue(Result(3))`.
5. Call `ToPrimitive(Result(2))`.
6. Call `ToPrimitive(Result(4))`.
7. If `Type(Result(5))` is `String` or `Type(Result(6))` is `String`, go to step 2. (Note that this step differs from step 3 in the algorithm for comparison for the relational operators in using `&r` instead of `and`.)
8. Call `ToNumber(Result(5))`.
9. Call `ToNumber(Result(6))`.
10. Apply the addition operation to `Result(8)` and `Result(9)`. See the discussion below.
11. Return `Result(10)`.
12. Call `ToString(Result(5))`.
13. Call `ToString(Result(6))`.
14. Concatenate `Result(12)` followed by `Result(13)`.
15. Return `Result(14)`.

Note that no hint is provided in the calls to `ToPrimitive` in steps 5 and 6. All native ECMAScript objects except `Date` objects handle the absence of a hint as if the hint `Number` were given; `Date` objects handle the absence of a hint as if the hint `String` were given. Host objects may handle the absence of a hint in some other manner.



## 11.6.2 The Subtraction Operator (-)

The production *AdditiveExpression* : *AdditiveExpression* - *MultiplicativeExpression* is evaluated as follows:

1. Evaluate *AdditiveExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *MultiplicativeExpression*.
4. Call GetValue(Result(3)).
5. Call ToNumber(Result(2)).
6. Call ToNumber(Result(4)).
7. Apply the subtraction operation to Result(5) and Result(6). See the discussion below (7.5.3).
8. Return Result(7).

## 11.6.3 Applying the Additive Operators (+, -) to Numbers

The + operator performs addition when applied to two operands of numeric type, producing the sum of the operands. The - operator performs subtraction, producing the difference of two numeric operands. Addition is a commutative operation, but not always associative.

The result of an addition is determined using the rules of IEEE 754 double-precision arithmetic:

- If either operand is NaN, the result is NaN.
- The sum of two infinities of opposite sign is NaN.
- The sum of two infinities of the same sign is the infinity of that sign.
- The sum of an infinity and a finite value is equal to the infinite operand.
- The sum of two negative zeros is -0. The sum of two positive zeros, or of two zeros of opposite sign, is +0.
- The sum of a zero and a nonzero finite value is equal to the nonzero operand.
- The sum of two nonzero finite values of the same magnitude and opposite sign is 0.
- In the remaining cases, where neither an infinity, nor a zero, nor NaN is involved, and the operands have the same sign or have different magnitudes, the sum is computed and rounded to the nearest representable value using IEEE 754 round-to-nearest mode. If the magnitude is too large to represent, the operation overflows and the result is then an infinity of appropriate sign. The ECMAScript language requires support of gradual underflow as defined by IEEE 754.

The - operator performs subtraction when applied to two operands of numeric type producing the difference of its operands; the left operand is the minuend and the right operand is the subtrahend. Given numeric operands *a* and *b*, it is always the case that *a*-*b* produces the same result as *a*+(-*b*).

## 11.7 BITWISE SHIFT OPERATORS

### Syntax

```
ShiftExpression :  
    AdditiveExpression  
    ShiftExpression << AdditiveExpression  
    ShiftExpression >> AdditiveExpression  
    ShiftExpression >>> AdditiveExpression
```

### Semantics

The result of evaluating *ShiftExpression* is always truncated to 32 bits. If the result of evaluating *ShiftExpression* produces a fractional component, the fractional component is discarded. The result of evaluating an *AdditiveExpression* that is the right-hand operand of a shift operator is always truncated to five bits.

### 11.7.1 The Left Shift Operator (<<)

Performs a bitwise left shift operation on the left argument by the amount specified by the right argument.

The production *ShiftExpression* : *ShiftExpression* << *AdditiveExpression* is evaluated as follows:

1. Evaluate *ShiftExpression*.
2. Call *GetValue(Result(1))*.
3. Evaluate *AdditiveExpression*.
4. Call *GetValue(Result(3))*.
5. Call *ToInt32(Result(2))*.
6. Call *ToInt32(Result(4))*.
7. Mask out all but the least significant 5 bits of *Result(6)*, that is, compute *Result(6) & 0x1F*.
8. Left shift *Result(5)* by *Result(7)* bits. The result is a signed 32 bit integer.
9. Return *Result(8)*.

### 11.7.2 The Signed Right Shift Operator (>> )

Performs a sign-filling bitwise right shift operation on the left argument by the amount specified by the right argument.

The production *ShiftExpression* : *ShiftExpression* >> *AdditiveExpression* is evaluated as follows:

1. Evaluate *ShiftExpression*.
2. Call *GetValue(Result(1))*.
3. Evaluate *AdditiveExpression*.
4. Call *GetValue(Result(3))*.
5. Call *ToInt32(Result(2))*.
6. Call *ToInt32(Result(4))*.
7. Mask out all but the least significant 5 bits of *Result(6)*, that is, compute *Result(6) & 0x1F*.
8. Perform sign-extending right shift of *Result(5)* by *Result(7)* bits. The most significant bit is propagated. The result is a signed 32 bit integer.
9. Return *Result(8)*.

### 11.7.3 The Unsigned Right Shift Operator (>>> )

Performs a zero-filling bitwise right shift operation on the left argument by the amount specified by the right argument.

The production *ShiftExpression* : *ShiftExpression* >>> *AdditiveExpression* is evaluated as follows:

1. Evaluate *ShiftExpression*.
2. Call *GetValue(Result(1))*.
3. Evaluate *AdditiveExpression*.
4. Call *GetValue(Result(3))*.
5. Call *ToUInt32(Result(2))*.
6. Call *ToInt32(Result(4))*.
7. Mask out all but the least significant 5 bits of *Result(6)*, that is, compute *Result(6) & 0x1F*.
8. Perform zero-filling right shift of *Result(5)* by *Result(7)* bits. Vacated bits are filled with zero. The result is an unsigned 32 bit integer.
9. Return *Result(8)*.

## 11.8 RELATIONAL OPERATORS

### Syntax

*RelationalExpression* :  
*ShiftExpression*  
*RelationalExpression* < *ShiftExpression*  
*RelationalExpression* > *ShiftExpression*  
*RelationalExpression* <= *ShiftExpression*  
*RelationalExpression* >= *ShiftExpression*

### Semantics

The production *RelationalExpression* : *RelationalExpression* < *ShiftExpression* is evaluated as follows:

1. Evaluate *RelationalExpression*.

2. Call GetValue(Result(1)).
3. Evaluate *ShiftExpression*.
4. Call GetValue(Result(3)).
5. Perform the comparison Result(2) < Result(4). (See below.)
6. If Result(5) is **undefined**, return **false**. Otherwise, return Result(5).

The production *RelationalExpression*: *RelationalExpression* > *ShiftExpression* is evaluated as follows:

1. Evaluate *RelationalExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *ShiftExpression*.
4. Call GetValue(Result(3)).
5. Perform the comparison Result(4) < Result(2). (See below.)
6. If Result(5) is **undefined**, return **false**. Otherwise, return Result(5).

The production *RelationalExpression*: *RelationalExpression* <= *ShiftExpression* is evaluated as follows:

1. Evaluate *RelationalExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *ShiftExpression*.
4. Call GetValue(Result(3)).
5. Perform the comparison Result(4) < Result(2). (See below.)
6. If Result(5) is **true** or **undefined**, return **false**. Otherwise, return **true**.

The production *RelationalExpression*: *RelationalExpression* >= *ShiftExpression* is evaluated as follows:

1. Evaluate *RelationalExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *ShiftExpression*.
4. Call GetValue(Result(3)).
5. Perform the comparison Result(2) < Result(4). (See below.)
6. If Result(5) is **true** or **undefined**, return **false**. Otherwise, return **true**.

The comparison  $x < y$ , where  $x$  and  $y$  are values, produces **true**, **false**, or **undefined** (which indicates that at least one operand is **NaN**). Such a comparison is performed as follows:

1. Call ToPrimitive( $x$ , hint Number).
2. Call ToPrimitive( $y$ , hint Number).
3. If Type(Result(1)) is String and Type(Result(2)) is String, go to step 16. (Note that this step differs from step 7 in the algorithm for the addition operator+ in using *and* instead of *or*.)
4. Call ToNumber(Result(1)).
5. Call ToNumber(Result(2)).
6. If Result(4) is **NaN**, return **undefined**.
7. If Result(5) is **NaN**, return **undefined**.
8. If Result(4) and Result(5) are the same number value, return **false**.
9. If Result(4) is +0 and Result(5) is -0, return **false**.
10. If Result(4) is -0 and Result(5) is +0, return **false**.
11. If Result(4) is +∞, return **false**.
12. If Result(5) is +∞, return **true**.
13. If Result(5) is -∞, return **false**.
14. If Result(4) is -∞, return **true**.
15. If the (finite, nonzero) mathematical value of Result(4) is less than the (finite, nonzero) mathematical value of Result(5), return **true**. Otherwise, return **false**.
16. If Result(2) is a prefix of Result (1), return **false**. (A string value  $p$  is a prefix of string value  $q$  if  $q$  can be the result of concatenating  $p$  and some other string  $r$ . Note that any string is a prefix of itself, because  $r$  may be the empty string.)
17. If Result(1) is a prefix of Result (2), return **true**.

18. Let  $k$  be the smallest nonnegative integer such that the character at position  $k$  within Result(1) is different from the character at position  $k$  within Result(2). (There must be such  $k$ , for neither string is a prefix of the other.)
19. Let  $m$  be the integer that is the Unicode encoding for the character at position  $k$  within Result(1).
20. Let  $n$  be the integer that is the Unicode encoding for the character at position  $k$  within Result(2).
21. If  $m < n$ , return **true**. Otherwise, return **false**.

## 11.9 EQUALITY OPERATORS

### Syntax

*EqualityExpression* :  
*RelationalExpression*  
*EqualityExpression* == *RelationalExpression*  
*EqualityExpression* != *RelationalExpression*

The production *EqualityExpression* : *EqualityExpression* == *RelationalExpression* is evaluated as follows:

1. Evaluate *EqualityExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *RelationalExpression*.
4. Call GetValue(Result(3)).
5. Perform the comparison Result(4) == Result(2). (See below.)
6. Return Result(5).

The production *EqualityExpression* : *EqualityExpression* != *RelationalExpression* is evaluated as follows:

1. Evaluate *EqualityExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *RelationalExpression*.
4. Call GetValue(Result(3)).
5. Perform the comparison Result(4) == Result(2). (See below.)
6. If Result(5) is **true**, return **false**. Otherwise, return **true**.

The comparison  $x == y$ , where  $x$  and  $y$  are values, produces **true** or **false**. Such a comparison is performed as follows:

1. If Type( $x$ ) is different from Type( $y$ ), go to step 14.
2. If Type( $x$ ) is Undefined, return **true**.
3. If Type( $x$ ) is Null, return **true**.
4. If Type( $x$ ) is not Number, go to step 11.
5. If  $x$  is NaN, return **false**.
6. If  $y$  is NaN, return **false**.
7. If  $x$  is the same number value as  $y$ , return **true**.
8. If  $x$  is +0 and  $y$  is -0, return **true**.
9. If  $x$  is -0 and  $y$  is +0, return **true**.
10. Return **false**.
11. If Type( $x$ ) is String, then return **true** if  $x$  and  $y$  are exactly the same sequence of characters (same length and same characters in corresponding positions). Otherwise, return **false**.
12. If Type( $x$ ) is Boolean, return **true** if  $x$  and  $y$  are both **true** or both **false**. Otherwise, return **false**.
13. Return **true** if  $x$  and  $y$  refer to the same object. Otherwise, return **false**.
14. If  $x$  is **null** and  $y$  is **undefined**, return **true**.
15. If  $x$  is **undefined** and  $y$  is **null**, return **true**.
16. If Type( $x$ ) is Number and Type( $y$ ) is String, return the result of the comparison ToString( $x$ ) ==  $y$ .
17. If Type( $x$ ) is String and Type( $y$ ) is Number, return the result of the comparison  $x$  == ToString( $y$ ).

18. If  $\text{Type}(x)$  is either String, Number, or Boolean and  $\text{Type}(y)$  is Object, return the result of the comparison  $x == \text{ToPrimitive}(y)$ .
19. If  $\text{Type}(x)$  is Object and  $\text{Type}(y)$  is either String, Number, or Boolean, return the result of the comparison  $\text{ToPrimitive}(x) == y$ .
20. Return **false**.

### Discussion

String comparison can be forced by: `"" + a == "" + b`.

Numeric comparison can be forced by: `a - 0 == b - 0`.

Boolean comparison can be forced by: `!a == !b`.

The equality operators maintain the following invariants:

1.  $A != B$  is equivalent to  $!(A == B)$ .
2.  $A == B$  is equivalent to  $B == A$ , except in the order of evaluation of A and B.

Note that the equality operator is not always transitive. For example, there might be two distinct String objects, each representing the same string value; each String object would be considered equal to the string value by the `==` operator, but the two String objects would not be equal to each other.

## 11.10 BINARY BITWISE OPERATORS

### Syntax

*BitwiseANDExpression:*  
*EqualityExpression*  
*BitwiseANDExpression & EqualityExpression*

*BitwiseXORExpression:*  
*BitwiseANDExpression*  
*BitwiseXORExpression ^ BitwiseANDExpression*

*BitwiseORExpression:*  
*BitwiseXORExpression*  
*BitwiseORExpression | BitwiseXORExpression*

### Semantics

The production  $A : A @ B$ , where @ is one of the bitwise operators in the productions above, is evaluated as follows:

1. Evaluate A.
2. Call `GetValue(Result(1))`.
3. Evaluate B.
4. Call `GetValue(Result(3))`.
5. Call `ToInt32(Result(2))`.
6. Call `ToInt32(Result(4))`.
7. Apply the bitwise operator @ to `Result(5)` and `Result(6)`. The result is a signed 32 bit integer.
8. Return `Result(7)`.

## 11.11 BINARY LOGICAL OPERATORS

### Syntax

*LogicalANDExpression:*  
*BitwiseORExpression*  
*LogicalANDExpression && BitwiseORExpression*

*LogicalORExpression:*  
*LogicalANDExpression*  
*LogicalORExpression || LogicalANDExpression*

### Semantics

The production *LogicalANDExpression* : *LogicalANDExpression* && *BitwiseORExpression* is evaluated as follows:

1. Evaluate *LogicalANDExpression*.
2. Call GetValue(Result(1)).
3. Call ToBoolean(Result(2)).
4. If Result(3) is false, return Result(2).
5. Evaluate *BitwiseORExpression*.
6. Call GetValue(Result(5)).
7. Return Result(6).

The production *LogicalORExpression* : *LogicalORExpression* | | *LogicalANDExpression* is evaluated as follows:

1. Evaluate *LogicalORExpression*.
2. Call GetValue(Result(1)).
3. Call ToBoolean(Result(2)).
4. If Result(3) is true, return Result(2).
5. Evaluate *LogicalANDExpression*.
6. Call GetValue(Result(5)).
7. Return Result(6).

## 11.12 CONDITIONAL OPERATOR ( ? : )

### Syntax

*ConditionalExpression* :  
*LogicalORExpression*  
*LogicalORExpression* ? *AssignmentExpression* : *AssignmentExpression*

### Semantics

The production *ConditionalExpression* : *LogicalORExpression* ? *AssignmentExpression* : *AssignmentExpression* is evaluated as follows:

1. Evaluate *LogicalORExpression*.
2. Call GetValue(Result(1)).
3. Call ToBoolean(Result(2)).
4. If Result(3) is false, go to step 8.
5. Evaluate the first *AssignmentExpression*.
6. Call GetValue(Result(5)).
7. Return Result(6).
8. Evaluate the second *AssignmentExpression*.
9. Call GetValue(Result(8)).
10. Return Result(9).

Issue: Add an explanation of how the grammar differs slightly from that of C and Java here.

## 11.13 ASSIGNMENT OPERATORS

### Syntax

*AssignmentExpression* :  
*ConditionalExpression*  
*LeftHandSideExpression* *AssignmentOperator* *AssignmentExpression*

*AssignmentOperator* :: one of  
= \*= /= %= += -= <<= >>= >>>= &= ^= |=

### 11.13.1 Simple Assignment (=)

The production *AssignmentExpression* : *LeftHandSideExpression* = *AssignmentExpression* is evaluated as follows:

1. Evaluate *LeftHandSideExpression*.
2. Evaluate *AssignmentExpression*.
3. Call GetValue(Result(2)).
4. Call PutValue(Result(1), Result(3)).
5. Return Result(3).

### 11.13.2 Compound Assignment (op= )

The production *AssignmentExpression*: *LeftHandSideExpression* @= *AssignmentExpression*, where @ represents one of operators indicated above, is evaluated as follows:

1. Evaluate *LeftHandSideExpression*.
2. Call GetValue(Result(1)).
3. Evaluate *AssignmentExpression*.
4. Call GetValue(Result(3)).
5. Apply operator @ to Result(2) and Result(4).
6. Call PutValue(Result(1), Result(5)).
7. Return Result(5).

### 11.14 COMMA OPERATOR ( , )

#### Syntax

*Expression* :  
*AssignmentExpression*  
*Expression* , *AssignmentExpression*

#### Semantics

The production *Expression* : *Expression* , *AssignmentExpression* is evaluated as follows:

1. Evaluate *Expression*.
2. Call GetValue(Result(1)).
3. Evaluate *AssignmentExpression*.
4. Call GetValue(Result(3)).
5. Return Result(4).

# 12 STATEMENTS

## Syntax

*Statement* :  
    *Block*  
    *VariableStatement*  
    *EmptyStatement*  
    *ExpressionStatement*  
    *IfStatement*  
    *IterationStatement*  
    *ContinueStatement*  
    *BreakStatement*  
    *ReturnStatement*  
    *WithStatement*

*Block* :  
    { *StatementList*<sub>opt</sub> }

*StatementList* :  
    *Statement*  
    *StatementList Statement*

## Semantics

The production *Block* : { } is evaluated as follows:

1. Return “normal completion”.

The production *Block* : { *StatementList* } is evaluated as follows:

1. Evaluate *StatementList*.
2. Return Result(1).

The production *StatementList* : *Statement* is evaluated as follows:

1. Evaluate *Statement*.
2. Return Result(1).

The production *StatementList* : *StatementList Statement* is evaluated as follows:

1. Evaluate *StatementList*.
2. If Result(1) is an abrupt completion, return Result(1).
3. Evaluate *Statement*.
4. If Result(3) is a value completion, return Result(3).
5. If Result(1) is not a value completion, return Result(3).
6. Let *V* be the value carried by Result(1).
7. If Result(3) is “abrupt completion because of **break**”, return “abrupt completion after value *V* because of **break**”.
8. If Result(3) is “abrupt completion because of **continue**”, return “abrupt completion after value *V* because of **continue**”.
9. Return “normal completion after value *V*”.



## 12.1 VARIABLE STATEMENT

### Syntax

*VariableStatement* :  
    **var** *VariableDeclarationList* ;

*VariableDeclarationList* :  
    *VariableDeclaration*  
    *VariableDeclarationList* , *VariableDeclaration*

*VariableDeclaration* :  
    *Identifier* *Initializer*<sub>opt</sub>

*Initializer* :  
    = *AssignmentExpression*

### Description

If the variable statement occurs inside a *FunctionDeclaration*, the variables are defined with function-local scope in that function. Otherwise, they are defined with global scope, that is, they are created as members of the global object as described in section **Error! Reference source not found.** Variables are created when the execution scope is entered. A *Block* does not define a new execution scope. Only *Program* and *FunctionDeclaration* produce a new scope. Eval code and anonymous code also define a new execution scope, but these are not an explicit part of the grammar of ECMAScript. Variables are initialized to the **undefined** value when created. A variable with an *Initializer* is assigned the value of its *AssignmentExpression* when the *VariableStatement* is executed.

### Semantics

The production *VariableStatement* : **var** *VariableDeclarationList* ; is evaluated as follows:

1. Evaluate *VariableDeclarationList*.
2. Return “normal completion”.

The production *VariableDeclarationList* : *VariableDeclaration* is evaluated by taking no action.

The production *VariableDeclarationList* : *VariableDeclarationList* , *VariableDeclaration* is evaluated as follows:

1. Evaluate *VariableDeclarationList*.
2. Evaluate *VariableDeclaration*.

The production *VariableDeclaration* : *Identifier* is evaluated as follows:

1. Evaluate *Identifier*.

ISSUE: Does it really evaluate the identifier, or does it take no action?

The production *VariableDeclaration* : *Identifier* *Initializer* is evaluated as follows:

1. Evaluate *Identifier*.
2. Evaluate *Initializer*.
3. Call GetValue(Result(2)).
4. Call PutValue(Result(1), Result(3)).

The production *Initializer* : = *AssignmentExpression* is evaluated as follows:

1. Evaluate *AssignmentExpression*.
2. Return Result(1).

## 12.2 EMPTY STATEMENT

### Syntax

*EmptyStatement* :  
    ;

### Semantics

The production *EmptyStatement* : ; is evaluated as follows:

1. Return “normal completion”.

## 12.3 EXPRESSION STATEMENT

### Syntax

*ExpressionStatement* :  
*Expression* ;

### Semantics

The production *ExpressionStatement* : *Expression* ; is evaluated as follows:

1. Evaluate *Expression*.
2. Call GetValue(Result(1)).
3. Return “normal completion after valueV”, where the value V is Result(2).

## 12.4 THE if STATEMENT

### Syntax

*IfStatement* :  
**if** ( *Expression* ) *Statement* **else** *Statement*  
**if** ( *Expression* ) *Statement*

### Semantics

The production *IfStatement* : **if** ( *Expression* ) *Statement* **else** *Statement* is evaluated as follows:

1. Evaluate *Expression*.
2. Call GetValue(Result(1)).
3. Call ToBoolean(Result(2)).
4. If Result(3) is **false**, go to step 7.
5. Evaluate the first *Statement*.
6. Return Result(5).
7. Evaluate the second *Statement*.
8. Return Result(7).

The production *IfStatement* : **if** ( *Expression* ) *Statement* is evaluated as follows:

1. Evaluate *Expression*.
2. Call GetValue(Result(1)).
3. Call ToBoolean(Result(2)).
4. If Result(3) is **false**, return “normal completion”.
5. Evaluate *Statement*.
6. Return Result(5).

## 12.5 ITERATION STATEMENTS

### Syntax

*IterationStatement* :  
**while** ( *Expression* ) *Statement*  
**for** ( *Expression*<sub>opt</sub> ; *Expression*<sub>opt</sub> ; *Expression*<sub>opt</sub> ) *Statement*  
**for** ( **var** *VariableDeclarationList* ; *Expression*<sub>opt</sub> ; *Expression*<sub>opt</sub> ) *Statement*  
**for** ( *LeftHandSideExpression* **in** *Expression* ) *Statement*  
**for** ( **var** *Identifier* *Initializer*<sub>opt</sub> **in** *Expression* ) *Statement*

### 12.5.1 The while Statement

The production *IterationStatement* : **while** ( *Expression* ) *Statement* is evaluated as follows:

1. Let C be “normal completion”.
2. Evaluate *Expression*.

3. Call GetValue(Result(1)).
4. Call ToBoolean(Result(2)).
5. If Result(3) is **false**, go to step 12.
6. Evaluate *Statement*.
7. If Result(6) a value completion, change *C* to be “normal completion after value *V*” where *V* is the value carried by Result(6).
8. If Result(6) is a **break** completion, go to step 12.
9. If Result(6) is a **continue** completion, go to step 1.
10. If Result(6) is a **return** completion, return Result(6).
11. Go to step 2.
12. Return *C*.

### 12.5.2 The `for` Statement

The production *IterationStatement*: **for** ( *Expression* ; *Expression* ; *Expression* ) *Statement* is evaluated as follows:

1. If the first *Expression* is not present, go to step 4.
2. Evaluate the first *Expression*.
3. Call GetValue(Result(2)). (This value is not used.)
4. Let *C* be “normal completion”.
5. If the second *Expression* is not present, go to step 9.
6. Evaluate the second *Expression*.
7. Call GetValue(Result(5)).
8. Call ToBoolean(Result(6)).
9. If Result(7) is **false**, go to step 19.
10. Evaluate *Statement*.
11. If Result(10) a value completion, change *C* to be “normal completion after value *V*” where *V* is the value carried by Result(6).
12. If Result(10) is a **break** completion, go to step 19.
13. If Result(10) is a **continue** completion, go to step 15.
14. If Result(10) is a **return** completion, return Result(10).
15. If the third *Expression* is not present, go to step 5.
16. Evaluate the third *Expression*.
17. Call GetValue(Result(11)). (This value is not used.)
18. Go to step 5.
19. Return *C*.

The production *IterationStatement*: **for** ( **var** *VariableDeclarationList* ; *Expression* ; *Expression* ) *Statement* is evaluated as follows:

1. Evaluate *VariableDeclarationList*
2. If the second *Expression* is not present, go to step 7.
3. Evaluate the second *Expression*.
4. Call GetValue(Result(3)).
5. Call ToBoolean(Result(4)).
6. If Result(5) is **false**, go to step 15.
7. Evaluate *Statement*.
8. If Result(7) is a **break** completion, go to step 15.
9. If Result(7) is a **continue** completion, go to step 11.
10. If Result(7) is a **return** completion, return Result(7).
11. If the third *Expression* is not present, go to step 2.
12. Evaluate the third *Expression*.
13. Call GetValue(Result(11)). (This value is not used.)
14. Go to step 2.
15. Return “normal completion”.

### 12.5.3 The `for...in` Statement

The production *IterationStatement*: `for ( LeftHandSideExpression in Expression ) Statement` is evaluated as follows:

1. Evaluate the *Expression*.
2. Call `GetValue(Result(1))`.
3. Call `ToObject(Result(2))`.
4. Get the name of the next property of `Result(3)` which doesn't have the `DontEnum` attribute. If there is no such property, go to step 12.
5. Evaluate the *LeftHandSideExpression* ( it may be evaluated repeatedly).
6. Call `PutValue(Result(5), Result(4))`.
7. Evaluate *Statement*.
8. If `Result(7)` a **break** completion, go to step 12.
9. If `Result(7)` a **continue** completion, go to step 4.
10. If `Result(7)` a **return** completion, return `Result(7)`.
11. Go to step 4.
12. Return "normal completion".

The production *IterationStatement*: `for ( var Identifier Initializeropt in Expression ) Statement` is evaluated as follows:

1. If the *Initializer* is not present, go to step 6.
2. Evaluate the *Identifier*.
3. Evaluate the *Initializer*.
4. Call `GetValue(Result(3))`.
5. Call `PutValue(Result(2), Result(4))`.
6. Evaluate the *Expression*.
7. Call `GetValue(Result(6))`.
8. Call `ToObject(Result(7))`.
9. Get the name of the next property of `Result(8)` which doesn't have the `DontEnum` attribute. If there is no such property, go to step 17.
10. Evaluate the *Identifier* (yes, it may be evaluated repeatedly).
11. Call `PutValue(Result(10), Result(9))`.
12. Evaluate *Statement*.
13. If `Result(12)` a **break** completion, go to step 17.
14. If `Result(12)` a **continue** completion, go to step 9.
15. If `Result(12)` a **return** completion, return `Result(12)`.
16. Go to step 9.
17. Return "normal completion".

The mechanics of enumerating the properties (step 4) is implementation dependent. The order of enumeration is defined by the object. Properties of the object being enumerated may be deleted during enumeration. If a property that has not yet been visited during enumeration is deleted, then it will not be visited. If new properties are added to the object being enumerated during enumeration, the newly added properties are not guaranteed to be visited in the active enumeration.

Enumerating the properties of an object includes enumerating properties of its prototype, and the prototype of the prototype, and so on, recursively; but a property of a prototype is not enumerated if it is "shadowed" because some previous object in the prototype chain has a property with the same name.

## 12.6 THE `continue` STATEMENT

### Syntax

```
ContinueStatement :  
    continue ;
```

An ECMAScript program is considered syntactically incorrect and may not be executed at all if it contains a **continue** statement that is not within at least one **while** or **for** statement. The **continue** statement is evaluated as:

1. Return “abrupt completion because of **continue**”.

## 12.7 THE **break** STATEMENT

### Syntax

*BreakStatement* :  
**break** ;

An ECMAScript program is considered syntactically incorrect and may not be executed at all if it contains a **break** statement that is not within at least one **while** or **for** statement. The **break** statement is evaluated as:

1. Return “abrupt completion because of **break**”.

## 12.8 THE **return** STATEMENT

### Syntax

*ReturnStatement* :  
**return** [no *LineTerminator* here] *Expression*<sub>opt</sub> ;

An ECMAScript program is considered syntactically incorrect and may not be executed at all if it contains a **return** statement that is not within the *Block* of a *FunctionDeclaration*. It causes a function to cease execution and return a value to the caller. If *Expression* is omitted, the return value is the **undefined** value. Otherwise, the return value is the value of *Expression*.

The production *ReturnStatement* :: **return** [no *LineTerminator* here] *Expression*<sub>opt</sub> ; is evaluated as:

1. If the *Expression* is not present, return “abrupt completion because of **return undefined**”.
2. Evaluate *Expression*.
3. Call `GetValue(Result(2))`.
4. Return “abrupt completion because of **return V**”, where the value *V* is `Result(3)`.

## 12.9 THE **with** STATEMENT

### Syntax

*WithStatement* :  
**with** ( *Expression* ) *Statement*

### Description

The **with** statement adds a computed object to the front of the scope chain of the current execution context, then executes a statement with this augmented scope chain, then restores the scope chain.

### Semantics

The production *WithStatement* :: **with** ( *Expression* ) *Statement* is evaluated as follows:

1. Evaluate *Expression*.
2. Call `GetValue(Result(1))`.
3. Call `ToObject(Result(2))`.
4. Add `Result(3)` to the front of the scope chain.
5. Evaluate *Statement* using the augmented scope chain from step 4.
6. Remove `Result(3)` from the front of the scope chain.
7. Return `Result(5)`.

### Discussion

Note that no matter how control leaves the embedded *Statement*, whether normally or by some form of abrupt completion, the scope chain is always restored to its former state.

## 13 FUNCTION DEFINITION

### Syntax

*FunctionDeclaration* :  
**function** *Identifier* ( *FormalParameterList*<sub>opt</sub> ) *Block*

*FormalParameterList* :  
*Identifier*  
*FormalParameterList* , *Identifier*

### Semantics

Defines a property of the global object whose name is the *Identifier* and whose value is a function object with the given parameter list and statements. If the function definition is supplied text to the **eval** function and the calling context has an activation object then the declared function is added to the activation object instead of to the global object.

The production *FunctionDeclaration* : **function** *Identifier* ( ) *Block* is processed for function declarations as follows:

1. Create a new Function object (15.3.2.1) with no parameters, the *Block* as the body, and *Identifier* as its name.
2. Put this new Function object as the new value of the property named *Identifier* in the global object or the activation object, as appropriate (see above).

The production *FunctionDeclaration* : **function** *Identifier* ( *FormalParameterList* ) *Block* is processed for function declarations as follows:

1. Create a new Function object (15.3.2.1) with the parameters specified by the *FormalParameterList*, the *Block* as the body, and *Identifier* as its name.
2. Put this new Function object as the new value of the property named *Identifier* in the global object or the activation object, as appropriate (see above).

# 14 PROGRAM

## Syntax

*Program* :  
    *SourceElements*

*SourceElements* :  
    *SourceElement*  
    *SourceElements SourceElement*

*SourceElement* :  
    *Statement*  
    *FunctionDeclaration*

The production *Program* : { *SourceElements* } is evaluated as follows:

1. Process *SourceElements* for function declarations.
2. Evaluate *SourceElements*.
3. Return Result(2).

The production *SourceElements*: *SourceElement* is processed for function declarations as follows:

1. Process *SourceElement* for function declarations

The production *SourceElements*: *SourceElement* is evaluated as follows:

1. Evaluate *SourceElement*
2. Return Result(1).

The production *SourceElements*: *SourceElements SourceElement* is processed for function declarations as follows:

1. Process *SourceElements* for function declarations
2. Process *SourceElement* for function declarations

The production *SourceElements*: *SourceElements SourceElement* is evaluated as follows:

1. Evaluate *SourceElements*.
2. Evaluate *SourceElement*.
3. If Result(2) is a value completion, return Result(2).
4. Return Result(1).

The production *SourceElement*: *Statement* is processed for function declarations by taking no action.

The production *SourceElement*: *Statement* is evaluated as follows:

1. Evaluate *Statement*.
2. Return Result(1).

The production *SourceElement*: *FunctionDeclaration* is processed for function declarations as follows:

1. Process *FunctionDeclaration* for function declarations

The production *SourceElement*: *FunctionDeclaration* is evaluated as follows:

1. Return "normal completion".

# 15 NATIVE ECMAScript OBJECTS

There are certain built-in objects available whenever an ECMAScript program begins execution. One, the global object, is in the scope chain of the executing program. Others are accessible as initial properties of the global object.

Many built-in objects are functions: they can be invoked with arguments. Some of them furthermore are constructors: they are functions intended for use with the `new` operator. A few of them are intended to be used both as ordinary functions and as constructors. For each built-in function, this specification describes the arguments required by that function and properties of the function object. For each built-in constructor, this specification furthermore describes properties of the prototype object of that constructor and properties of specific object instances returned by `new` expression that invokes that constructor.

Unless otherwise specified in the description of a particular function, if a function or constructor described in this section is given fewer arguments than the function is specified to require, the function or constructor shall behave exactly as if it had been given sufficient additional arguments, each such argument being the `undefined` value.

None of the built-in functions described in this section shall initially have an `arguments` property.

None of the built-in functions described in this section shall initially have a `prototype` property unless otherwise specified in the description of a particular function. Every built-in function object described in this section—whether as a constructor, an ordinary function, or both—has a `length` property whose value is an integer. Unless otherwise specified, this value is equal to the number of named arguments shown in the section heading for the function description; for example, the function object that is the initial value of the `indexOf` property (section 0) of the String prototype object is described under the section heading “`indexOf(searchString, position)`” which shows the two named arguments *searchString* and *position*; therefore the value of the `length` property of that function object is 2. Sometimes the same function object is described under more than one heading to emphasize its different behaviors when given different numbers of actual arguments; in such a case, unless otherwise specified, the `length` value is the largest number of arguments shown in any applicable section heading. For example, the function object that is the initial value of the `Object` property of the global object is described under four separate headings: as a function of one argument (section 5.2.1.1), as a function of zero arguments (section 15.2.1.2), as a constructor of one argument (15.2.2.1), and as a constructor of zero arguments (15.2.2.2). The largest number of arguments described is 1, so that value of the `length` property of that function object is 1.

In every case, a `length` property of a built-in function object described in this section has the attributes { `ReadOnly`, `DontDelete`, `DontEnum` } (and no others). Every other property described in this section has the attribute { `DontEnum` } (and no others) unless otherwise specified.

## 15.1 THE GLOBAL OBJECT

The global object does not have a `[[Construct]]` property; it is not possible to use the global object as a constructor with the `new` operator.

### 15.1.1 Value Properties of the Global Object

#### 15.1.1.1 NaN

The initial value of `NaN` is `NaN`.



### 15.1.1.2 Infinity

The initial value of `Infinity` is  $+\infty$ .

## 15.1.2 Function Properties of the Global Object

### 15.1.2.1 `eval(x)`

When the `eval` function is called with one argument  $x$ , the following steps are taken:

1. If  $x$  is not a string value, return  $x$ .
2. Parse  $x$  as an ECMAScript *Program*. If the parse fails, generate a runtime error.
3. Evaluate the program from step 2.
4. If Result(3) is “normal completion after value  $V$ ”, return the value  $V$ .
5. Return **undefined**.

### 15.1.2.2 `parseInt(string, radix)`

The `parseInt` function produces an integer value dictated by interpretation of the contents of the *string* argument according to the specified *radix*.

When the `parseInt` function is called, the following steps are taken:

1. Call `ToString(string)`.
2. Compute a substring of Result(1) consisting of the leftmost character that is not a *StrWhiteSpaceChar* and all characters to the right of that character. (In other words, remove leading whitespace.)
3. Let *sign* be 1.
4. If Result(2) is not empty and the first character of Result(2) is a minus sign `-`, let *sign* be  $-1$ .
5. If Result(2) is not empty and the first character of Result(2) is a plus sign `+` or a minus sign `-`, then Result(5) is the substring of Result(2) produced by removing the first character; otherwise, Result(5) is Result(2).
6. If the *radix* argument is not supplied, go to step 12.
7. Call `ToInt32(radix)`.
8. If Result(7)  $< 2$  or Result(7)  $> 36$ , return **NaN**.
9. Let  $R$  be Result(7).
10. If  $R = 16$  and the length of Result(5) is at least 2 and the first two characters of Result(5) are either “`0x`” or “`0X`”, let  $S$  be the substring of Result(5) consisting of all but the first two characters; otherwise, let  $S$  be Result(5).
11. Go to step 22.
12. If Result(5) is not empty and the first character of Result(5) is `no0`, go to step 20.
13. If the length of Result(5) is at least 2 and the second character of Result(5) is `ix` or `x`, go to step 17.
14. Let  $R$  be 8.
15. Let  $S$  be the substring of Result(5) consisting of all but the first character.
16. Go to step 22.
17. Let  $R$  be 16.
18. Let  $S$  be the substring of Result(5) consisting of all but the first two characters.
19. Go to step 22.
20. Let  $R$  be 10.
21. Let  $S$  be Result(5).
22. If  $S$  contains any character that is not a radix  $R$  digit, then let  $Z$  be the substring of  $S$  consisting of all characters to the left of the leftmost such character; otherwise, let  $Z$  be  $S$ .
23. If  $Z$  is empty, return **NaN**.
24. Compute the mathematical integer value that is represented by  $Z$  in radix- $R$  notation.
25. Compute the number value for Result(24).
26. Return  $sign \cdot \text{Result}(25)$ .

Note that `parseInt` may interpret only a leading portion of the string as an integer value; it ignores any characters that cannot be interpreted as part of the notation of an integer, and no indication is given that any such characters were ignored.

### 15.1.2.3 parseFloat(string)

The **parseFloat** function produces a number value dictated by interpretation of the contents of the *string* argument as a decimal literal.

When the **parseFloat** function is called, the following steps are taken:

1. Call **ToString**(*string*).
2. Compute a substring of **Result**(1) consisting of the leftmost character that is not a *StrWhiteSpaceChar* and all characters to the right of that character. (In other words, remove leading whitespace.)
3. If neither **Result**(2) nor any prefix of **Result**(2) satisfies the syntax of *StrDecimalLiteral* (see 9.3.1), return **NaN**.
4. Compute the longest prefix of **Result**(2), which might be **Result**(2) itself, that satisfies the syntax of a *StrDecimalLiteral*.
5. Return the number value for the MV of **Result**(4).

Note that **parseFloat** may interpret only a leading portion of the string as a number value; it ignores any characters that cannot be interpreted as part of the notation of an decimal literal, and no indication is given that any such characters were ignored.

### 15.1.2.4 escape(string)

The **escape** function computes a new version of a string value in which certain have been replaced by a hexadecimal escape sequence. The result thus contains no special characters that might have special meaning within a URL.

For characters whose Unicode encoding is **0xFF** or less, a two-digit escape sequence of the form **%xx** is used in accordance with RFC1738. For characters whose Unicode encoding is greater than **0xFF**, a four-digit escape sequence of the form **%uxxxx** is used

When the **escape** function is called with one argument *string*, the following steps are taken:

1. Call **ToString**(*string*).
2. Compute the number of characters in **Result**(1).
3. Let *R* be the empty string.
4. Let *k* be 0.
5. If *k* equals **Result**(2), return *R*.
6. Get the character at position *k* within **Result**(1).
7. If **Result**(6) is one of the 62 nonblank ASCII characters **ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789 @\*\_+-./,** go to step 14.
8. Compute the 16-bit unsigned integer that is the Unicode character encoding of **Result**(6).
9. If **Result**(8), is less than 256, go to step 12.
10. Let *S* be a string containing six characters **%uwxxyz** where *wxyz* are four hexadecimal digits encoding the value of **Result**(8).
11. Go to step 15.
12. Let *S* be a string containing three characters **%xy** where *xy* are two hexadecimal digits encoding the value of **Result**(8).
13. Go to step 15.
14. Let *S* be a string containing the single character **Result**(6).
15. Let *R* be a new string value computed by concatenating the previous value of *R* and *S*.
16. Increase *k* by 1.
17. Go to step 5.

### 15.1.2.5 unescape(string)

The **unescape** function computes a new version of a string value in which each escape sequences of the sort that might be introduced by the **escape** function is replaced with the character that it represents.

When the **unescape** function is called with one argument *string*, the following steps are taken:

1. Call **ToString**(*string*).
2. Compute the number of characters in **Result**(1).

3. Let  $R$  be the empty string.
4. Let  $k$  be 0.
5. If  $k$  equals `Result(2)`, return  $R$ .
6. Let  $c$  be the character at position  $k$  within `Result(1)`.
7. If  $c$  is not `%`, go to step 17.
8. If  $k$  is greater than `Result(2)-6`, go to step 14.
9. If the character at position  $k+1$  within `result(1)` is `not u`, go to step 14.
10. If the four characters at positions  $k+2$ ,  $k+3$ ,  $k+4$ , and  $k+5$  within `Result(1)` are not all hexadecimal digits, go to step 14.
11. Let  $c$  be the character whose Unicode encoding is the integer represented by the four hexadecimal digits at positions  $k+2$ ,  $k+3$ ,  $k+4$ , and  $k+5$  within `Result(1)`.
12. Increase  $k$  by 5.
13. Go to step
14. If  $k$  is greater than `Result(2)-3`, go to step 18.
15. If the two characters at positions  $k+1$  and  $k+2$  within `Result(1)` are not both hexadecimal digits, go to step 18.
16. Let  $c$  be the character whose Unicode encoding is the integer represented by two zeroes plus the two hexadecimal digits at positions  $k+1$  and  $k+2$  within `Result(1)`.
17. Increase  $k$  by 2.
18. Let  $R$  be a new string value computed by concatenating the previous value of  $R$  and  $c$ .
19. Increase  $k$  by 1.
20. Go to step 5.

#### 15.1.2.6 `isNaN(number)`

Applies `ToNumber` to its argument, then returns **true** if the result is **NaN**, and otherwise returns **false**.

#### 15.1.2.7 `isFinite(number)`

Applies `ToNumber` to its argument, then returns **false** if the result is **NaN**,  $+\infty$ , or  $-\infty$ , and otherwise returns **true**.

## 15.2 OBJECT OBJECTS

### 15.2.1 The Object Constructor Called as a Function

When `object` is called as a function rather than as a constructor, it performs a type conversion.

#### 15.2.1.1 `Object(value)`

When the `object` function is called with one argument *value*, the following steps are taken:

1. If the *value* is **null** or **undefined**, create and return a new object with no properties (other than internal properties) exactly as for the expression `new Object()`.
2. Return `ToObject(value)`.

#### 15.2.1.2 `Object()`

When the `object` function is called with no arguments, the following step is taken:

1. Create and return a new object with no properties (other than internal properties) exactly as for the expression `new Object()`.

### 15.2.2 The Object Constructor

When `object` is called as part of a `new` expression, it is a constructor that may create an object.

#### 15.2.2.1 `new Object(value)`

When the `object` constructor is called with one argument *value*, the following steps are taken:

1. If the type of the *value* is not `Object`, go to step 4.

2. If the value is a native ECMAScript object, do not create a new object; simply return *value*.
3. If the value is a host object, then actions are taken and a result is returned in an implementation-dependent manner that may depend on the host object.
4. If the type of the value is not String, go to step 6.
5. Create a new native ECMAScript object to serve as a “wrapper” for the string value  
 The `[[Prototype]]` property of the newly constructed object is set to the original String prototype object, the one that is the initial value of `String.prototype`  
 The `[[Class]]` property of the newly constructed object is set to `"String"`.  
 The `[[Value]]` property of the newly constructed object is set to *value*.  
 Return the newly created native object.
6. If the type of the value is not Boolean, go to step 8.
7. Create a new native ECMAScript object to serve as a “wrapper” for the boolean value  
 The `[[Prototype]]` property of the newly constructed object is set to the original Boolean prototype object, the one that is the initial value of `Boolean.prototype`  
 The `[[Class]]` property of the newly constructed object is set to `"Boolean"`.  
 The `[[Value]]` property of the newly constructed object is set to *value*.  
 Return the newly created native object.
8. If the type of the value is not Number, go to step 10.
9. Create a new native ECMAScript object to serve as a “wrapper” for the number value  
 The `[[Prototype]]` property of the newly constructed object is set to the original Number prototype object, the one that is the initial value of `Number.prototype`  
 The `[[Class]]` property of the newly constructed object is set to `"Number"`.  
 The `[[Value]]` property of the newly constructed object is set to *value*.  
 Return the newly created native object.
10. (The type of the value must be Null or Undefined.) Create a new native ECMAScript object.  
 The `[[Prototype]]` property of the newly constructed object is set to the Object prototype object.  
 The `[[Class]]` property of the newly constructed object is set to `"Object"`.  
 The newly constructed object has no `[[Value]]` property.  
 Return the newly created native object.

#### 15.2.2.2 new Object()

When the `Object` constructor is called with no argument, the following step is taken:

1. Create a new native ECMAScript object.  
 The `[[Prototype]]` property of the newly constructed object is set to the Object prototype object.  
 The `[[Class]]` property of the newly constructed object is set to `"Object"`.  
 The newly constructed object has no `[[Value]]` property.  
 Return the newly created native object.

### 15.2.3 Properties of the Object Constructor

The value of the internal `[[Prototype]]` property of the Object constructor is the Function prototype object.

Besides the internal `[[Call]]` and `[[Construct]]` properties and the `length` property, the Object constructor has the following properties:

#### 15.2.3.1 Object.prototype

The initial value of `Object.prototype` is the built-in Object prototype object.

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.2.4 Properties of the Object Prototype Object

#### 15.2.4.1 Object.prototype.constructor

The initial value of `Object.prototype.constructor` is the built-in `Object` constructor.

#### 15.2.4.2 Object.prototype.toString()

When the `toString` method is called, the following steps are taken:

1. Get the `[[Class]]` property of this object.
2. Call `ToString(Result(1))`.
3. Compute a string value by concatenating the three strings `"Object "`, `Result(2)`, and `"`.
4. Return `Result(3)`.

#### 15.2.4.3 Object.prototype.valueOf()

As a rule, the `valueOf` method for an object simply returns the object; but if the object is a “wrapper” for a host object, as may perhaps be created by the `Object` constructor (see section 5.2.2.1), then the contained host object should be returned.

When the `valueOf` method is called, the following steps are taken:

1. Get the `[[Class]]` property of this object.
2. If `Result(1)` is `"Object"`, return this object.
3. Get the `[[Value]]` property of this object.
4. If `Result(3)` is `undefined`, return this object.
5. Return `Result(3)`.

### 15.2.5 Properties of Object Instances

Object instances have no special properties beyond those inherited from the `Object` prototype object.

## 15.3 FUNCTION OBJECTS

### 15.3.1 The Function Constructor Called as a Function

When `Function` is called as a function rather than as a constructor, it creates and initializes a new function object. Thus the function call `Function(...)` is equivalent to the object creation expression `new Function(...)` with the same arguments.

#### 15.3.1.1 Function(p1, p2, . . . , pn, body)

When the `Function` function is called with some arguments `p1, p2, . . . , pn, body` (where  $n$  might be 0, that is, there are no “ $p$ ” arguments), the following steps are taken:

1. Create and return a new `Function` object exactly as for the expression `new Function(p1, p2, . . . , pn, body)`.

### 15.3.2 The Function Constructor

When `Function` is called as part of a `new` expression, it is a constructor: it initializes the newly created object.

#### 15.3.2.1 Function(p1, p2, . . . , pn, body)

The last argument specifies the body (executable code) of a function; any preceding arguments specify formal parameters.

When the `Function` constructor is called with some arguments `p1, p2, . . . , pn, body` (where  $n$  might be 0, that is, there are no “ $p$ ” arguments), the following steps are taken:

1. Let  $P$  be the empty string.
2. If no arguments were given, let  $body$  be the empty string and go to step 13.
3. If one argument was given, let  $body$  be that argument and go to step 13.
4. Let  $A$  be the first argument.
5. Let  $P$  be `ToString(Result(4))`.
6. Let  $k$  be 2.
7. If  $k$  equals the number of arguments, let  $body$  be the  $k$ 'th argument and go to step 13.
8. Let  $A$  be the  $k$ 'th argument.
9. Call `ToString(Result(8))`.

10. Let  $P$  be the result of concatenating the previous value of  $P$ , the string `,` (a comma), and `Result(9)`.
11. Increase  $k$  by 1.
12. Go to step 7.
13. Call `ToString(body)`.
14. Let  $F$  be the newly constructed Function object.
15. The `[[Class]]` property of  $F$  is set to `"Function"`.
16. Set the `[[Call]]` property of  $F$  to a method such that, when it is invoked, the executable function will be invoked whose formal parameters are specified by  $P$  and whose body is specified by `Result(13)`. The string value  $P$  must be parsable as a *FormalParameterList<sub>opt</sub>*; the string value `result(13)` must be parsable as a *StatementList<sub>opt</sub>*. (Note that both  $P$  and `Result(13)` may contain whitespace, line terminators, and comments.) However, if either  $P$  or `Result(13)` is syntactically incorrect, or otherwise cannot be interpreted as part of a correct ECMAScript function definition, then the `[[Call]]` property of  $F$  is not set and a runtime error is generated.
17. Set the `[[Construct]]` property of  $F$  to a method that, when it is invoked, constructs a new object whose `[[Prototype]]` property is equal to the value of  $F$ .`prototype` at the time the `[[Construct]]` method is invoked, then invokes  $F$  as a function (using its `[[Call]]` property) with the new object as the `this` value and the arguments given to the `[[Construct]]` method as the arguments. If the result of invoking the `[[Call]]` method is an object, that object becomes the result of the invocation of the `[[Construct]]` method; otherwise the new object becomes the result of the invocation of the `[[Construct]]` method.
18. If the `toString` method of  $F$  is later invoked, it will use `"anonymous"` as the name of the function in rendering the function as a string.
19. Compute, as an integer number value of positive sign, the number of formal parameters that resulted from the parse of  $P$  as a *FormalParameterList<sub>opt</sub>*.
20. The `length` property of  $F$  is set to `Result(18)`. This property is given attributes {`DontDelete`, `DontEnum`, `ReadOnly`}.
21. Create a new object as if by the expression `new Object()`.
22. The `prototype` property of  $F$  is set to `Result(21)`. This property is given attributes {`DontEnum`}.
23. The `constructor` property of `Result(21)` is set to  $F$ . This property is given attributes {`DontEnum`}.
24. The `arguments` property of  $F$  is set to `null`. This property is given attributes {`DontDelete`, `DontEnum`, `ReadOnly`}.

Note that it is permissible but not necessary to have one argument for each formal parameter to be specified. For example, all three of the following expressions produce the same result:

```
new Function("a", "b", "c", "return a+b+c")
new Function("a, b, c", "return a+b+c")
new Function("a,b", "c", "return a+b+c")
```

A `prototype` property is automatically created for every function, against the possibility that the function will be used as a constructor. However, note that this prototype object is not automatically given a `constructor` property. It is conventional for a prototype object to have a `constructor` property whose value is the Function object whose `prototype` property has that prototype as its value, but the creation of this property, if that is desired, is the responsibility of the programmer.

### 15.3.3 Properties of the Function Constructor

#### 15.3.3.1 Function.prototype

The initial value of `Function.prototype` is the built-in Function prototype object. This property shall have the attributes {`DontEnum`, `ReadOnly`}.

#### 15.3.3.2 Function.length

The `length` property is 1. (Of course, the Function constructor accepts more than one argument, because it accepts a variable number of arguments.)

### 15.3.4 Properties of the Function Prototype Object

Note that the Function prototype object is itself a Function object. It is a function with an “empty body”; if it is invoked, it merely returns `undefined`.

The Function prototype object does not have a `valueOf` property of its own; however, it inherits the `valueOf` property from the Object prototype Object.

#### 15.3.4.1 `Function.prototype.constructor`

The initial value of `Function.prototype.constructor` is the built-in `Function` constructor.

#### 15.3.4.2 `Function.prototype.toString()`

An implementation-dependent representation of the function is returned. This representation has the syntax of a *FunctionDeclaration*. Note in particular that the use and placement of whitespace, line terminators, and semicolons within the representation string is implementation-dependent.

The `toString` function is not generic; it generates a runtime error if its `this` value is not a Function object. Therefore it cannot be transferred to other kinds of objects for use as a method.

### 15.3.5 Properties of Function Instances

Every function instance has a `[[Call]]` property and a `[[Construct]]` property.

#### 15.3.5.1 `length`

The value of the `length` property is usually an integer that indicates the “typical” number of arguments expected by the function. However, the language permits the function to be invoked with some other number of arguments. The behavior of a function when invoked on a number of arguments other than the number specified by its `length` property depends on the function.

#### 15.3.5.2 `prototype`

The value of the `prototype` property is used to initialize the internal `[[Prototype]]` property of a newly created object before the Function object is invoked as a constructor for that newly created object.

#### 15.3.5.3 `arguments`

The value of the `arguments` property is normally `null` if there is no outstanding invocation of the function in progress (that is, the function has been called but has not yet returned). When a non-internal Function object (15.3.2.1) is invoked, its `arguments` property is “dynamically bound” to a newly created object that contains the arguments on which it was invoked (see 0.1.6 and 10.1.8). Note that the use of this property is discouraged; it is provided principally for compatibility with existing old code.

## 15.4 ARRAY OBJECTS

Array objects give special treatment to a certain class of property names. A property name  $P$  (in the form of a string value) is an *array index* if and only if `ToString(ToUint32( $P$ ))` is equal to  $P$  and `ToUint32( $P$ )` is not equal to  $2^{32}-1$ . Every Array object has a `length` property whose value is always an integer with positive sign and less than  $2^{32}$ . It is always the case that the `length` property is numerically greater than the name of every property whose name is an array index; whenever a property of an Array object is created or changed, other properties are adjusted as necessary to maintain this invariant. Specifically, whenever a property is added whose name is an array index, the `length` property is changed, if necessary, to be one more than the numeric value of that array index; and whenever the `length` property is changed, every property whose name is an array index whose value is not smaller than the new length is automatically deleted. This constraint applies only to properties of the Array object itself and is unaffected by `length` or array index properties that may be inherited from its prototype.

## 15.4.1 The Array Constructor

When **Array** is called as part of a **new** expression, it is a constructor: it initializes the newly created object.

### 15.4.1.1 new Array(item0, item1, . . .)

This description applies if and only if the Array constructor is given two or more arguments.

The `[[Class]]` property of the newly constructed object is set to **"Array"**.

The `length` property of the newly constructed object is set to the number of arguments.

The `0` property of the newly constructed object is set to *item0*; the `1` property of the newly constructed object is set to *item1*; and, in general, for as many arguments as there are, the `k` property of the newly constructed object is set to argument *k*, where the first argument is considered to be argument number `0`.

### 15.4.1.2 new Array(len)

The `[[Class]]` property of the newly constructed object is set to **"Array"**.

If the argument *len* is a number, then the `length` property of the newly constructed object is set to *len*.

If the argument *len* is not a number, then the `length` property of the newly constructed object is set to `1` and the `0` property of the newly constructed object is set to *len*.

### 15.4.1.3 new Array()

The `[[Class]]` property of the newly constructed object is set to **"Array"**.

The `length` property of the newly constructed object is set to `0`.

## 15.4.2 Properties of the Array Constructor

The value of the internal `[[Prototype]]` property of the Array constructor is the Function prototype object.

Besides the internal `[[Call]]` and `[[Construct]]` properties, the Array constructor has the following properties:

### 15.4.2.1 Array.prototype

The initial value of **Array.prototype** is the built-in Array prototype object.

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.4.2.2 Array.length

The `length` property is `1`. (Of course, the Array constructor accepts more than one argument, because it accepts a variable number of arguments.)

## 15.4.3 Properties of the Array Prototype Object

Note that the Array prototype object is itself an array; it has a `length` property (whose initial value is `+0`) and the special internal `[[Put]]` method described in section 15.4.4.1. In following descriptions of functions that are properties of the Array prototype object, the phrase "this object" refers to the object that is the **this** value for the invocation of the function. It is permitted for **this** to refer to an object for which the value of the internal `[[Class]]` property is not **"Array"**.

### 15.4.3.1 Array.prototype.constructor

The initial value of **Array.prototype.constructor** is the built-in **Array** constructor.

### 15.4.3.2 Array.prototype.toString()

The elements of this object are converted to strings, and these strings are then concatenated, separated by comma characters. The result is the same as if the built-in **join** method were invoked for this object with no argument.



### 15.4.3.3 Array.prototype.valueOf()

The elements of this object are converted to strings, and these strings are then concatenated, separated by comma characters. The result is the same as if the built-in `join` method were invoked for this object with no argument.

In other words, for Array objects, `valueOf` does the same thing as `toString`.

### 15.4.3.4 Array.prototype.join(separator)

The elements of the array are converted to strings, and these strings are then concatenated, separated by occurrences of the *separator*. If no separator is provided, a single comma is used as the separator.

When the `join` method is called with one argument *separator*, the following steps are taken:

1. Call the `[[Get]]` method of this object with argument `"length"`.
2. Call `ToUint32(Result(1))`.
3. If *separator* is undefined or not supplied, let *separator* be the single-character string `,`.
4. Call `ToString(separator)`.
5. If `Result(2)` is `0`, return the empty string.
6. Call the `[[Get]]` method of this object with argument `0`.
7. If `Result(6)` is **undefined** or **null**, use the empty string; otherwise, call `ToString(Result(6))`.
8. Let *R* be `Result(7)`.
9. Let *k* be `1`.
10. If *k* equals `Result(2)`, return *R*.
11. Let *S* be a string value produced by concatenating *R* and `Result(4)`.
12. Call the `[[Get]]` method of this object with argument *k*.
13. If `Result(12)` is **undefined** or **null**, use the empty string; otherwise, call `ToString(Result(12))`.
14. Let *R* be a string value produced by concatenating *S* and `Result(13)`.
15. Increase *k* by `1`.
16. Go to step 10.

Note that the `join` function is intentionally generic; it does not require that its `this` value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method.

### 15.4.3.5 Array.prototype.reverse()

The elements of the array are rearranged so as to reverse their order. This object is returned as the result of the call.

1. Call the `[[Get]]` method of this object with argument `"length"`.
2. Call `ToUint32(Result(1))`.
3. Compute `floor(Result(2)/2)`.
4. Let *k* be `0`.
5. If *k* equals `Result(3)`, return this object.
6. Compute `Result(2)-k-1`.
7. Call the `[[Get]]` method of this object with argument *k*.
8. Call the `[[Get]]` method of this object with argument `Result(6)`.
9. Call the `[[Put]]` method of this object with arguments *k* and `Result(8)`.
10. Call the `[[Put]]` method of this object with arguments `Result(6)` and `Result(7)`.
11. Increase *k* by `1`.
12. Go to step 5.

Note that the `reverse` function is intentionally generic; it does not require that its `this` value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method.

### 15.4.3.6 Array.prototype.sort(comparefn)

The elements of this array are sorted. The sort is not necessarily stable. If `comparefn` is provided, it should be a function that accepts two arguments *x* and *y* and returns a negative value if  $x < y$ , zero if  $x = y$ , or a positive value if  $x > y$ .

1. Call the `[[Get]]` method of this object with argument `"length"`.

2. Call `ToUint32(Result(1))`.
3. If *comparefn* is supplied, `Result(3)` is *comparefn*. Otherwise, `Result(3)` is the `SortCompare` operator of two arguments, which is described below.
4. Perform an implementation-dependent sequence of calls to the `[[Get]]` and `[[Put]]` methods of this object and to `Result(3)`, where the first argument for each call to `[[Get]]` and `[[Put]]` is a nonnegative integer less than `Result(2)` and where the arguments for calls to `Result(3)` are results of previous calls to the `[[Get]]` method. After this sequence is complete, this object must have the following two properties.
  - (1) There must be some mathematical permutation  $\pi$  of the nonnegative integers less than `Result(2)`, such that for every nonnegative integer *j* less than `Result(2)`, `new[ $\pi(j)$ ]` is exactly the same value as `old[j]`.
  - (2) If *comparefn* is a consistent comparison function for the elements of this array, then for all nonnegative integers *j* and *k*, each less than `Result(2)`, if `old[j]` compares less than `old[k]`, then  $\pi(j) < \pi(k)$ .

Here we use the notation `old[j]` to refer to the hypothetical result of calling the `[[Get]]` method of this object with argument *j* before this step is executed, and the notation `new[j]` to refer to the hypothetical result of calling the `[[Get]]` method of this object with argument *j* after this step has been completely executed.

A function is a consistent comparison function for a set of values if (a) for any two of those values (possibly the same value) considered as an ordered pair, it always returns the same value when given that pair of values as its two arguments, and the result of applying `ToNumber` to this value is not `NaN`; (b) when considered as a relation, where the pair (*x*, *y*) is considered to be in the relation if and only if applying the function to *x* and *y* and then applying `ToNumber` to the result produces a negative value, this relation is a partial order; and (c) when considered as a different relation, where the pair (*x*, *y*) is considered to be in the relation if and only if applying the function to *x* and *y* and then applying `ToNumber` to the result produces a zero value (of either sign), this relation is an equivalence relation. In this context, the phrase “*x* compares less than *y*” means applying `Result(2)` to *x* and *y* and then applying `ToNumber` to the result produces a negative value
5. Return this object.

When the `SortCompare` operator (the default comparison operation for the `sort` method) is called with two arguments *x* and *y*, the following steps are taken:

1. If *x* is **undefined**, return 1.
2. If *y* is **undefined**, return -1.
3. Call `ToString(x)`.
4. Call `ToString(y)`.
5. If `Result(3) < Result(4)`, return -1.
6. If `Result(3) > Result(4)`, return 1.
7. Return +0.

Note that the `sort` function is intentionally generic; it does not require that its `this` value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method.

#### 15.4.4 Properties of Array Instances

Array instances inherit properties from the Array prototype object and also have the following properties.

##### 15.4.4.1 `[[Put]](P, V)`

Array objects use a variation of the `[[Put]]` method used for other native ECMAScript objects (section 8.6.2.2).

Assume *A* is an Array object and *P* is a string.

When the `[[Put]]` method of *A* is called with property *P* and value *V*, the following steps are taken:

1. Call the `[[CanPut]]` method of *A* with name *P*.
2. If `Result(1)` is false, return.
3. If *A* doesn't have a property with name *P*, go to step 7.
4. If *P* is **"length"**, go to step 12.

5. Set the value of property *P* of *A* to *V*.
6. Go to step 8.
7. Create a property with name *P*, set its value to *V* and give it empty attributes.
8. If *P* is not an array index, return.
9. If *A* itself has a property (not an inherited property) named "**length**", and `ToUint32(P)` is less than the value of the **length** property of *A*, then return.
10. Change (or set) the value of the **length** property of *A* to `ToUint32(P)+1`.
11. Return.
12. Compute `ToUint32(V)`.
13. For every integer *k* that is less than the value of the **length** property of *A* but not less than `Result(12)`, if *A* itself has a property (not an inherited property) named `Tostring(k)`, then delete that property.
14. Set the value of property *P* of *A* to `Result(12)`.
15. Return.

#### 15.4.4.2 length

The **length** property of this Array object is always numerically greater than the name of every property whose name is an array index.

The **length** property has the `DontDelete` attribute.

## 15.5 STRING OBJECTS

### 15.5.1 The String Constructor Called as a Function

When **string** is called as a function rather than as a constructor, it performs a type conversion.

#### 15.5.1.1 String(value)

Returns a string value (not a String object) computed by `Tostring(value)`.

#### 15.5.1.2 String()

Returns the empty string "".

### 15.5.2 The String Constructor

When **string** is called as part of a **new** expression, it is a constructor: it initializes the newly created object.

#### 15.5.2.1 new String(value)

The `[[Class]]` property of the newly constructed object is set to **String**.

The `[[Value]]` property of the newly constructed object is set to `Tostring(value)`.

#### 15.5.2.2 new String()

The `[[Class]]` property of the newly constructed object is set to **String**.

The `[[Value]]` property of the newly constructed object is set to the empty string.

### 15.5.3 Properties of the String Constructor

The value of the internal `[[Prototype]]` property of the String constructor is the Function prototype object.

Besides the internal `[[Call]]` and `[[Construct]]` properties and the **length** property, the String constructor has the following property

#### 15.5.3.1 String.prototype

The initial value of **string.prototype** is the built-in String prototype object.

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.5.3.2 String.fromCharCode(char0, char1, . . .)

Returns a string value containing as many characters as the number of arguments. Each argument specifies one character of the resulting string, with the first argument specifying the first character, and so on, from left to right. An argument is converted to a character by applying the operation ToUint16 (section 9.7) and regarding the resulting 16-bit integer as the Unicode encoding of a character. If no arguments are supplied, the result is the empty string.

## 15.5.4 Properties of the String Prototype Object

In following descriptions of functions that are properties of the String prototype object, the phrase “this String object” refers to the object that is the **this** value for the invocation of the function; it is an error if **this** does not refer to an object for which the value of the internal `[[Class]]` property is not **"string"**. Also, the phrase “this string value” refers to the string value represented by this String object, that is, the value of the internal `[[Value]]` property of this String object.

### 15.5.4.1 String.prototype.constructor

The initial value of **String.prototype.constructor** is the built-in **String** constructor.

### 15.5.4.2 String.prototype.toString()

Returns this string value. (Note that, for a String object, the **toString** method happens to return the same thing as the **valueOf** method.)

The **toString** function is not generic; it generates a runtime error if its **this** value is not a String object. Therefore it cannot be transferred to other kinds of objects for use as a method.

### 15.5.4.3 String.prototype.valueOf()

Returns this string value.

The **valueOf** function is not generic; it generates a runtime error if its **this** value is not a String object. Therefore it cannot be transferred to other kinds of objects for use as a method.

### 15.5.4.4 String.prototype.charAt(pos)

Returns a string containing the character at position *pos* in this string. If there is no character at that position, the result is the empty string. The result is a string value, not a String object.

If *pos* is a value of Number type, then the result of **x.charAt(pos)** is equal to the result of **x.substring(pos, pos+1)** except in the strange case where *pos* is greater than **-1** but less than **0**.

When the **charAt** method is called with one argument *pos*, the following steps are taken:

1. Call **ToString**, giving it the **this** value as its argument.
2. Call **ToInteger(pos)**.
3. Compute the number of characters in **Result(1)**.
4. If **Result(2)** is less than 0 or is not less than **Result(3)**, return the empty string.
5. Return a string of length 1, containing one character from **Result(1)**, namely the character at position **Result(2)**, where the first (leftmost) character in **Result(1)** is considered to be at position 0, the next one at position 1, and so on.

Note that the **charAt** function is intentionally generic; it does not require that its **this** value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

### 15.5.4.5 String.prototype.charCodeAt(pos)

Returns a number (a nonnegative integer less than  $2^{16}$ ) representing the Unicode encoding of the character at position *pos* in this string. If there is no character at that position, the result is **NaN**.

When the **charCodeAt** method is called with one argument *pos*, the following steps are taken:

1. Call **ToString**, giving it the **this** value as its argument.
2. Call **ToInteger(pos)**.

3. Compute the number of characters in Result(1).
4. If Result(2) is less than 0 or is not less than Result(3), return **NaN**.
5. Return a value of Number type, of positive sign, whose magnitude is the Unicode encoding of one character from Result(1), namely the character at position Result(2), where the first (leftmost) character in Result(1) is considered to be at position 0, the next one at position 1, and so on.

Note that the `charCodeAt` function is intentionally generic; it does not require that its `this` value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

#### 15.5.4.6 String.prototype.indexOf(searchString, position)

If the given `searchString` appears as a substring of the result of converting this object to a string, at one or more positions that are at or to the right of the specified position, then the index of the leftmost such position is returned; otherwise `-1` is returned. If `position` is undefined or not supplied, 0 is assumed, so as to search all of the string.

When the `indexOf` method is called with two arguments `searchString` and `position`, the following steps are taken:

1. Call `ToString`, giving it the `this` value as its argument.
2. Call `ToString(searchString)`.
3. Call `ToInteger(position)`. (If `position` is **undefined** or not supplied, this step produces the value 0).
4. Compute the number of characters in Result(1).
5. Compute `min(max(Result(3), 0), Result(4))`.
6. Compute the number of characters in the string that is Result(2).
7. Compute the smallest possible integer `k` not smaller than Result(5) such that `k+Result(6)` is not greater than Result(4), and for all nonnegative integers `j` less than Result(6), the character at position `k+j` of Result(1) is the same as the character at position `j` of Result(2); but if there is no such integer `k`, then compute the value `-1`.
8. Return Result(7).

Note that the `indexOf` function is intentionally generic; it does not require that its `this` value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

#### 15.5.4.7 String.prototype.lastIndexOf(searchString, position)

If the given `searchString` appears as a substring of the result of converting this object to a string, at one or more positions that are at or to the left of the specified position, then the index of the rightmost such position is returned; otherwise `-1` is returned. If `position` is undefined or not supplied, the length of this string value is assumed, so as to search all of the string.

When the `lastIndexOf` method is called with two arguments `searchString` and `position`, the following steps are taken:

1. Call `ToString`, giving it the `this` value as its argument.
2. Call `ToString(searchString)`.
3. Call `ToNumber(position)`.
4. If Result(3) is **NaN**, use `+∞`; otherwise, call `ToInteger(Result(3))`.
5. Compute the number of characters in Result(1).
6. Compute `min(max(Result(4), 0), Result(5))`.
7. Compute the number of characters in the string that is Result(2).
8. Compute the largest possible integer `k` not larger than Result(6) such that `k+Result(7)` is not greater than Result(5), and for all nonnegative integers `j` less than Result(7), the character at position `k+j` of Result(1) is the same as the character at position `j` of Result(2); but if there is no such integer `k`, then compute the value `-1`.
9. Return Result(8).

Note that the `lastIndexOf` function is intentionally generic; it does not require that its `this` value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

#### 15.5.4.8 String.prototype.split(separator)

Returns an Array object into which substrings of the result of converting this object to a string have been stored. The substrings are determined by searching from left to right for occurrences of the given

separator; these occurrences are not part of any substring in the returned array, but serve to divide up this string value. The separator may be a string of any length.

As a special case, if the separator is the empty string, the string is split up into individual characters; the length of the result array equals the length of the string, and each substring contains one character.

If the separator is not supplied, then the result array contains just one string, which is the string.

When the `split` method is called with one argument *separator*, the following steps are taken:

1. Call `ToString`, giving it the `this` value as its argument.
2. Create a new Array object of length 0 and call it *A*.
3. If *separator* is undefined or not supplied, call the `[[Put]]` method of *A* with 0 and `Result(1)` as arguments, and then return *A*.
4. Call `ToString(separator)`.
5. Compute the number of characters in `Result(1)`.
6. Compute the number of characters in the string that is `Result(4)`.
7. Let *p* be 0.
8. If `Result(6)` is zero (the separator string is empty), go to step 17.
9. Compute the smallest possible integer *k* not smaller than *p* such that *k*+`Result(6)` is not greater than `Result(5)`, and for all nonnegative integers *j* less than `Result(6)`, the character at position *k*+*j* of `Result(1)` is the same as the character at position *j* of `Result(2)`; but if there is no such integer *k*, then go to step 14.
10. Compute a string value equal to the substring of `Result(1)`, consisting of the characters at positions *p* through *k*-1, inclusive.
11. Call the `[[Put]]` method of *A* with *A*.`length` and `Result(10)` as arguments.
12. Let *p* be *k*+`Result(6)`.
13. Go to step 9.
14. Compute a string value equal to the substring of `Result(1)`, consisting of the characters from position *p* to the end of `Result(1)`.
15. Call the `[[Put]]` method of *A* with *A*.`length` and `Result(13)` as arguments.
16. Return *A*.
17. If *p* equals `Result(5)`, return *A*.
18. Compute a string value equal to the substring of `Result(1)`, consisting of the single character at position *p*.
19. Call the `[[Put]]` method of *A* with *A*.`length` and `Result(17)` as arguments.
20. Increase *p* by 1.
21. Go to step 17.

Note that the `split` function is intentionally generic; it does not require that its `this` value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

#### 15.5.4.9 String.prototype.substring(start)

Returns a substring of the result of converting this object to a string, starting from character position *start* and running to the end of the string. The result is a string value, not a String object.

If the argument is NaN or negative, it is replaced with zero; if the argument is larger than the length of the string, it is replaced with the length of the string.

When the `substring` method is called with one argument *start*, the following steps are taken:

1. Call `ToString`, giving it the `this` value as its argument.
2. Call `ToInteger(start)`.
3. Compute the number of characters in the string that is the value of the `[[Value]]` property of `this`.
4. Compute `min(max(Result(2), 0), Result(3))`.
5. Return a string whose length is the difference between `Result(3)` and `Result(4)`, containing characters from the string that is the value of the `[[Value]]` property of `this`, namely the characters with indices `Result(4)` through `Result(3)-1`, in ascending order.

#### 15.5.4.10 String.prototype.substring(start, end)

Returns a substring of the result of converting this object to a string, starting from character position *start* and running to character position *end* of the string. The result is a string value, not a String object.

If either argument is NaN or negative, it is replaced with zero; if either argument is larger than the length of the string, it is replaced with the length of the string.

If *start* is larger than *end*, they are swapped.

When the **substring** method is called with two arguments *start* and *end*, the following steps are taken:

1. Call `ToString`, giving it the **this** value as its argument.
2. Call `ToInteger(start)`.
3. Call `ToInteger(end)`.
4. Compute the number of characters in `Result(1)`.
5. Compute `min(max(Result(2), 0), Result(4))`.
6. Compute `min(max(Result(3), 0), Result(4))`.
7. Compute `min(Result(5), Result(6))`.
8. Compute `max(Result(5), Result(6))`.
9. Return a string whose length is the difference between `Result(8)` and `Result(7)`, containing characters from `Result(1)`, namely the characters with indices `Result(7)` through `Result(8)`, in ascending order.

Note that the **substring** function is intentionally generic; it does not require that its **this** value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

#### 15.5.4.11 String.prototype.toLowerCase

Returns a string equal in length to the length of the result of converting this object to a string. The result is a string value, not a String object.

Every character of the result is equal to the corresponding character of the string, unless that character has a Unicode 2.0 lowercase equivalent, in which case the lowercase equivalent is used instead.

Note that the **toLowerCase** function is intentionally generic; it does not require that its **this** value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

#### 15.5.4.12 String.prototype.toUpperCase

Returns a string equal in length to the length of the result of converting this object to a string. The result is a string value, not a String object.

Every character of the result is equal to the corresponding character of the string, unless that character has a Unicode 2.0 uppercase equivalent, in which case the uppercase equivalent is used instead.

Note that the **toUpperCase** function is intentionally generic; it does not require that its **this** value be a String object. Therefore it can be transferred to other kinds of objects for use as a method.

### 15.5.5 Properties of String Instances

String instances inherit properties from the String prototype object and also have a `[[Value]]` property and a `length` property.

The `[[Value]]` property is the string value represented by this String object.

#### 15.5.5.1 length

The number of characters in the String value represented by this String object.

Once a String object is created, this property is unchanging.

## 15.6 BOOLEAN OBJECTS

### 15.6.1 The Boolean Constructor Called as a Function

When **Boolean** is called as a function rather than as a constructor, it performs a type conversion.

#### 15.6.1.1 Boolean(value)

Returns a boolean value (not a Boolean object) computed by `ToBoolean(value)`.

### 15.6.1.2 Boolean()

Returns **false**.

## 15.6.2 The Boolean Constructor

When **Boolean** is called as part of a **new** expression, it is a constructor: it initializes the newly created object.

### 15.6.2.1 new Boolean(value)

The `[[Class]]` property of the newly constructed Boolean object is set to **"Boolean"**.

The `[[Value]]` property of the newly constructed Boolean object is set to `ToBoolean(value)`.

### 15.6.2.2 new Boolean()

The `[[Class]]` property of the newly constructed Boolean object is set to **"Boolean"**.

The `[[Value]]` property of the newly constructed Boolean object is set to **false**.

## 15.6.3 Properties of the Boolean Constructor

The value of the internal `[[Prototype]]` property of the Boolean constructor is the Function prototype object.

Besides the internal `[[Call]]` and `[[Construct]]` properties and the `length` property, the Boolean constructor has the following property:

### 15.6.3.1 Boolean.prototype

The initial value of `Boolean.prototype` is the built-in Boolean prototype object.

This property shall have the attributes { DontEnum, ReadOnly }.

## 15.6.4 Properties of the Boolean Prototype Object

In following descriptions of functions that are properties of the Boolean prototype object, the phrase “this Boolean object” refers to the object that is the **this** value for the invocation of the function; it is an error if **this** does not refer to an object for which the value of the internal `[[Class]]` property is not **"Boolean"**. Also, the phrase “this boolean value” refers to the boolean value represented by this Boolean object, that is, the value of the internal `[[Value]]` property of this Boolean object.

### 15.6.4.1 Boolean.prototype.constructor

The initial value of `Boolean.prototype.constructor` is the built-in **Boolean** constructor.

### 15.6.4.2 Boolean.prototype.toString()

If this boolean value is **true**, then the string **"true"** is returned. Otherwise, this boolean value must be **false**, and therefore the string **"false"** is returned.

The `toString` function is not generic; it generates a runtime error if its **this** value is not a Boolean object. Therefore it cannot be transferred to other kinds of objects for use as a method.

### 15.6.4.3 Boolean.prototype.valueOf()

Returns this boolean value.

The `valueOf` function is not generic; it generates a runtime error if its **this** value is not a Boolean object. Therefore it cannot be transferred to other kinds of objects for use as a method.

## 15.6.5 Properties of Boolean Instances

Boolean instances have no special properties beyond those inherited from the Boolean prototype object.



## 15.7 NUMBER OBJECTS

### 15.7.1 The Number Constructor Called as a Function

When **Number** is called as a function rather than as a constructor, it performs a type conversion.

#### 15.7.1.1 Number(value)

Returns a number value (not a Number object) computed by `ToNumber(value)`.

#### 15.7.1.2 Number()

Returns `+0`.

### 15.7.2 The Number Constructor

When **Number** is called as part of a **new** expression, it is a constructor: it initializes the newly created object.

#### 15.7.2.1 new Number(value)

The `[[Class]]` property of the newly constructed object is set to `"Number"`.

The `[[Value]]` property of the newly constructed object is set to `ToNumber(value)`.

#### 15.7.2.2 new Number()

The `[[Class]]` property of the newly constructed object is set to `"Number"`.

The `[[Value]]` property of the newly constructed object is set to `+0`.

### 15.7.3 Properties of the Number Constructor

The value of the internal `[[Prototype]]` property of the Number constructor is the Function prototype object.

Besides the internal `[[Call]]` and `[[Construct]]` properties and the `length` property, the Number constructor has the following property:

#### 15.7.3.1 Number.prototype

The initial value of `Number.prototype` is the built-in Number prototype object.

This property shall have the attributes { DontEnum, ReadOnly }.

#### 15.7.3.2 Number.MAX\_VALUE

The value of `Number.MAX_VALUE` is the largest positive finite value of the number type, which is approximately `1.7976931348623157e308`.

This property shall have the attributes { DontEnum, ReadOnly }.

#### 15.7.3.3 Number.MIN\_VALUE

The value of `Number.MIN_VALUE` is the smallest positive nonzero value of the number type, which is approximately `5e-324`.

This property shall have the attributes { DontEnum, ReadOnly }.

#### 15.7.3.4 Number.NaN

The value of `Number.NaN` is `NaN`.

This property shall have the attributes { DontEnum, ReadOnly }.

#### 15.7.3.5 Number.NEGATIVE\_INFINITY

The value of `Number.NEGATIVE_INFINITY` is `-∞`.

This property shall have the attributes { DontEnum, ReadOnly }.

#### 15.7.3.6 Number.POSITIVE\_INFINITY

The value of `Number.POSITIVE_INFINITY` is  $+\infty$ .

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.7.4 Properties of the Number Prototype Object

In following descriptions of functions that are properties of the Number prototype object, the phrase “this Number object” refers to the object that is the `this` value for the invocation of the function; it is an error if `this` does not refer to an object for which the value of the internal `[[Class]]` property is not `"Number"`. Also, the phrase “this number value” refers to the number value represented by this Number object, that is, the value of the internal `[[Value]]` property of this Number object.

#### 15.7.4.1 Number.prototype.constructor

The initial value of `Number.prototype.constructor` is the built-in `Number` constructor.

#### 15.7.4.2 Number.prototype.toString()

This number value is given as an argument to the `ToString` operator ; the resulting string value is returned.

The `toString` function is not generic; it generates a runtime error if its `this` value is not a Number object. Therefore it cannot be transferred to other kinds of objects for use as a method.

#### 15.7.4.3 Number.prototype.valueOf()

Returns this number value.

The `valueOf` function is not generic; it generates a runtime error if its `this` value is not a Number object. Therefore it cannot be transferred to other kinds of objects for use as a method.

### 15.7.5 Properties of Number Instances

Number instances have no special properties beyond those inherited from the Number prototype object.

## 15.8 THE MATH OBJECT

The Math object is merely a single object that has some named properties, some of which are functions.

The Math object does not have a `[[Construct]]` property; it is not possible to use the Math object as a constructor with the `new` operator.

Recall that, in this specification, the phrase “the number value for  $x$ ” means “the value of number type, not NaN but possibly infinite, that is closer than any other value of number type to the mathematical value  $x$ , but if  $x$  lies exactly halfway between two such values then the number value whose least significant bit is 0 is chosen”.

### 15.8.1 Value Properties of the Math Object

#### 15.8.1.1 E

The number value for  $e$ , the base of the natural logarithms, which is approximately

**2.7182818284590452354**

This property shall have the attributes { DontEnum, ReadOnly }.

#### 15.8.1.2 LN10

The number value for the natural logarithm of 10, which is approximately **2.302585092994046**

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.8.1.3 LN2

The number value for the natural logarithm of 2, which is approximately **0.6931471805599453**

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.8.1.4 LOG2E

The number value for the base-2 logarithm of *e*, the base of the natural logarithms; this value is approximately **1.4426950408889634** (Note that the value of **Math.LOG2E** is approximately the reciprocal of the value of **Math.LN2**.)

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.8.1.5 LOG10E

The number value for the base-2 logarithm of *e*, the base of the natural logarithms; this value is approximately **0.4342944819032518** (Note that the value of **Math.LOG2E** is approximately the reciprocal of the value of **Math.LN2**.)

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.8.1.6 PI

The number value for  $\pi$ , the ratio of the circumference of a circle to its diameter, which is approximately **3.14159265358979323846**

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.8.1.7 SQRT1\_2

The number value for the square root of 1/2, which is approximately **0.7071067811865476** (Note that the value of **Math.SQRT1\_2** is approximately the reciprocal of the value of **Math.SQRT2**.)

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.8.1.8 SQRT2

The number value for the square root of 2, which is approximately **1.4142135623730951**

This property shall have the attributes { DontEnum, ReadOnly }.

## 15.8.2 Function Properties of the Math Object

Every function listed in this section applies the ToNumber operator to each of its arguments (in left-to-right order if there is more than one) and then performs a computation on the resulting number value(s).

The behavior of the functions **acos**, **asin**, **atan**, **atan2**, **cos**, **exp**, **log**, **pow**, **sin**, and **sqrt** is not precisely specified here. They are intended to compute approximations to the results of familiar mathematical functions, but some latitude is allowed in the choice of approximation algorithms. The general intent is that an implementor should be able to use the same mathematical library for ECMAScript on a given hardware platform that is available to C programmers on that platform. Nevertheless, this specification recommends (though it does not require) the approximation algorithms for IEEE 754 arithmetic contained in **fdlibm**, the freely distributable mathematical library [XXXREF]. This specification also requires specific results for certain argument values that represent boundary cases of interest.

### 15.8.2.1 abs(x)

Returns the absolute value of its argument; in general, the result has the same magnitude as the argument but has positive sign.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **-0**, the result is **+0**.
- If the argument is **-∞**, the result is **+∞**.

### 15.8.2.2 $\text{acos}(x)$

Returns an implementation-dependent approximation to the arc cosine of the argument. The result is expressed in radians and ranges from  $+0$  to  $+\pi$ .

- If the argument is **NaN**, the result is **NaN**.
- If the argument is greater than **1**, the result is **NaN**.
- If the argument is less than **-1**, the result is **NaN**.
- If the argument is exactly **1**, the result is  $+0$ .

### 15.8.2.3 $\text{asin}(x)$

Returns an implementation-dependent approximation to the arc sine of the argument. The result is expressed in radians and ranges from  $-\pi/2$  to  $+\pi/2$ .

- If the argument is **NaN**, the result is **NaN**.
- If the argument is greater than **1**, the result is **NaN**.
- If the argument is less than **-1**, the result is **NaN**.
- If the argument is  $+0$ , the result is  $+0$ .
- If the argument is  $-0$ , the result is  $-0$ .

### 15.8.2.4 $\text{atan}(x)$

Returns an implementation-dependent approximation to the arc tangent of the argument. The result is expressed in radians and ranges from  $-\pi/2$  to  $+\pi/2$ .

- If the argument is **NaN**, the result is **NaN**.
- If the argument is  $+0$ , the result is  $+0$ .
- If the argument is  $-0$ , the result is  $-0$ .
- If the argument is  $+\infty$ , the result is an implementation-dependent approximation to  $\pi/2$ .
- If the argument is  $-\infty$ , the result is an implementation-dependent approximation to  $-\pi/2$ .

### 15.8.2.5 $\text{atan2}(y, x)$

Returns an implementation-dependent approximation to the arc tangent of the quotient  $y/x$  of the arguments  $y$  and  $x$ , where the signs of the arguments are used to determine the quadrant of the result. Note that it is intentional and traditional for the two-argument arc tangent function that the argument named  $y$  be first and the argument named  $x$  be second. The result is expressed in radians and ranges from  $-\pi$  to  $+\pi$ .

- If either argument is **NaN**, the result is **NaN**.
- If  $y > 0$  and  $x$  is  $+0$ , the result is an implementation-dependent approximation to  $\pi/2$ .
- If  $y > 0$  and  $x$  is  $-0$ , the result is an implementation-dependent approximation to  $\pi/2$ .
- If  $y$  is  $+0$  and  $x > 0$ , the result is  $+0$ .
- If  $y$  is  $+0$  and  $x$  is  $+0$ , the result is  $+0$ .
- If  $y$  is  $+0$  and  $x$  is  $-0$ , the result is an implementation-dependent approximation to  $\pi$ .
- If  $y$  is  $+0$  and  $x < 0$ , the result is an implementation-dependent approximation to  $\pi$ .
- If  $y$  is  $-0$  and  $x > 0$ , the result is  $-0$ .
- If  $y$  is  $-0$  and  $x$  is  $+0$ , the result is  $-0$ .
- If  $y$  is  $-0$  and  $x$  is  $-0$ , the result is an implementation-dependent approximation to  $-\pi$ .
- If  $y$  is  $-0$  and  $x < 0$ , the result is an implementation-dependent approximation to  $-\pi$ .
- If  $y < 0$  and  $x$  is  $+0$ , the result is an implementation-dependent approximation to  $-\pi/2$ .
- If  $y < 0$  and  $x$  is  $-0$ , the result is an implementation-dependent approximation to  $-\pi/2$ .
- If  $y > 0$  and  $y$  is finite and  $x$  is  $+\infty$ , the result is  $+0$ .
- If  $y > 0$  and  $y$  is finite and  $x$  is  $-\infty$ , the result is an implementation-dependent approximation to  $\pi$ .
- If  $y < 0$  and  $y$  is finite and  $x$  is  $+\infty$ , the result is  $-0$ .
- If  $y < 0$  and  $y$  is finite and  $x$  is  $-\infty$ , the result is an implementation-dependent approximation to  $-\pi$ .
- If  $y$  is  $+\infty$  and  $x$  is finite, the result is an implementation-dependent approximation to  $\pi/2$ .
- If  $y$  is  $-\infty$  and  $x$  is finite, the result is an implementation-dependent approximation to  $-\pi/2$ .

- If  $y$  is  $+\infty$  and  $x$  is  $+\infty$ , the result is an implementation-dependent approximation to  $\pi/4$ .
- If  $y$  is  $+\infty$  and  $x$  is  $-\infty$ , the result is an implementation-dependent approximation to  $+\pi/4$ .
- If  $y$  is  $-\infty$  and  $x$  is  $+\infty$ , the result is an implementation-dependent approximation to  $-\pi/4$ .
- If  $y$  is  $-\infty$  and  $x$  is  $-\infty$ , the result is an implementation-dependent approximation to  $-3\pi/4$ .

#### 15.8.2.6 `ceil(x)`

Returns the smallest (closest to  $-\infty$ ) number value that is not less than the argument and is equal to a mathematical integer. If the argument is already an integer, the result is the argument itself.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **+0**, the result is **+0**.
- If the argument is **-0**, the result is **-0**.
- If the argument is  $+\infty$ , the result is  $+\infty$ .
- If the argument is  $-\infty$ , the result is  $-\infty$ .
- If the argument is less than 0 but greater than **-1**, the result is **-0**.

The value of `Math.ceil(x)` is the same as the value of `-Math.floor(-x)`.

#### 15.8.2.7 `cos(x)`

Returns an implementation-dependent approximation to the cosine of the argument. The argument is expressed in radians.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **+0**, the result is **1**.
- If the argument is **-0**, the result is **1**.
- If the argument is  $+\infty$ , the result is **NaN**.
- If the argument is  $-\infty$ , the result is **NaN**.

#### 15.8.2.8 `exp(x)`

Returns an implementation-dependent approximation to the exponential function of the argument ( $e$  raised to the power of the argument, where  $e$  is the base of the natural logarithms).

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **+0**, the result is **1**.
- If the argument is **-0**, the result is **1**.
- If the argument is  $+\infty$ , the result is  $+\infty$ .
- If the argument is  $-\infty$ , the result is **+0**.

#### 15.8.2.9 `floor(x)`

Returns the greatest (closest to  $+\infty$ ) number value that is not greater than the argument and is equal to a mathematical integer. If the argument is already an integer, the result is the argument itself.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **+0**, the result is **+0**.
- If the argument is **-0**, the result is **-0**.
- If the argument is  $+\infty$ , the result is  $+\infty$ .
- If the argument is  $-\infty$ , the result is  $-\infty$ .
- If the argument is greater than 0 but less than **1**, the result is **+0**.

The value of `Math.floor(x)` is the same as the value of `-Math.ceil(-x)`.

#### 15.8.2.10 `log(x)`

Returns an implementation-dependent approximation to natural logarithm of the argument.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is less than 0, the result is **NaN**.
- If the argument is **+0** or **-0**, the result is  $-\infty$ .
- If the argument is **1**, the result is **+0**.

- If the argument is  $+\infty$ , the result is  $+\infty$ .

#### 15.8.2.11 `max(x, y)`

Returns the larger of the two arguments.

- If either argument is **NaN**, the result is **NaN**.
- If  $x > y$ , the result is  $x$ .
- If  $y > x$ , the result is  $y$ .
- If  $x$  is  $+0$  and  $y$  is  $+0$ , the result is  $+0$ .
- If  $x$  is  $+0$  and  $y$  is  $-0$ , the result is  $+0$ .
- If  $x$  is  $-0$  and  $y$  is  $+0$ , the result is  $+0$ .
- If  $x$  is  $-0$  and  $y$  is  $-0$ , the result is  $-0$ .

#### 15.8.2.12 `min(x, y)`

Returns the smaller of the two arguments.

- If either argument is **NaN**, the result is **NaN**.
- If  $x < y$ , the result is  $x$ .
- If  $y < x$ , the result is  $y$ .
- If  $x$  is  $+0$  and  $y$  is  $+0$ , the result is  $+0$ .
- If  $x$  is  $+0$  and  $y$  is  $-0$ , the result is  $-0$ .
- If  $x$  is  $-0$  and  $y$  is  $+0$ , the result is  $-0$ .
- If  $x$  is  $-0$  and  $y$  is  $-0$ , the result is  $-0$ .

#### 15.8.2.13 `pow(x, y)`

Returns an implementation-dependent approximation to the result of raising  $x$  to the power  $y$ .

- If  $y$  is **NaN**, the result is **NaN**.
- If  $y$  is  $+0$ , the result is  $1$ , even if  $x$  is **NaN**.
- If  $y$  is  $-0$ , the result is  $1$ , even if  $x$  is **NaN**.
- If  $x$  is **NaN** and  $y$  is nonzero, the result is **NaN**.
- If  $\text{abs}(x) > 1$  and  $y$  is  $+\infty$ , the result is  $+\infty$ .
- If  $\text{abs}(x) > 1$  and  $y$  is  $-\infty$ , the result is  $+0$ .
- If  $\text{abs}(x) == 1$  and  $y$  is  $+\infty$ , the result is **NaN**.
- If  $\text{abs}(x) == 1$  and  $y$  is  $-\infty$ , the result is **NaN**.
- If  $\text{abs}(x) < 1$  and  $y$  is  $+\infty$ , the result is  $+0$ .
- If  $\text{abs}(x) < 1$  and  $y$  is  $-\infty$ , the result is  $+\infty$ .
- If  $x$  is  $+\infty$  and  $y > 0$ , the result is  $+\infty$ .
- If  $x$  is  $+\infty$  and  $y < 0$ , the result is  $+0$ .
- If  $x$  is  $-\infty$  and  $y > 0$  and  $y$  is an odd integer, the result is  $-\infty$ .
- If  $x$  is  $-\infty$  and  $y > 0$  and  $y$  is not an odd integer, the result is  $+\infty$ .
- If  $x$  is  $-\infty$  and  $y < 0$  and  $y$  is an odd integer, the result is  $-0$ .
- If  $x$  is  $-\infty$  and  $y < 0$  and  $y$  is not an odd integer, the result is  $+0$ .
- If  $x$  is  $+0$  and  $y > 0$ , the result is  $+0$ .
- If  $x$  is  $+0$  and  $y < 0$ , the result is  $+\infty$ .
- If  $x$  is  $-0$  and  $y > 0$  and  $y$  is an odd integer, the result is  $-0$ .
- If  $x$  is  $-0$  and  $y > 0$  and  $y$  is not an odd integer, the result is  $+0$ .
- If  $x$  is  $-0$  and  $y < 0$  and  $y$  is an odd integer, the result is  $-\infty$ .
- If  $x$  is  $-0$  and  $y < 0$  and  $y$  is not an odd integer, the result is  $+\infty$ .
- If  $x < 0$  and  $x$  is finite and  $y$  is finite and  $y$  is not an integer, the result is **NaN**.

#### 15.8.2.14 random()

Returns a number value with positive sign, greater than or equal to 0 but less than 1, chosen randomly or pseudorandomly with approximately uniform distribution over that range, using an implementation-dependent algorithm or strategy. This function takes no arguments.

#### 15.8.2.15 round(x)

Returns the number value that is closest to the argument and is equal to a mathematical integer. If two integer number values are equally close to the argument, then the result is the number value that is closer to  $+\infty$ . If the argument is already an integer, the result is the argument itself.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **+0**, the result is **+0**.
- If the argument is **-0**, the result is **-0**.
- If the argument is  $+\infty$ , the result is  $+\infty$ .
- If the argument is  $-\infty$ , the result is  $-\infty$ .
- If the argument is greater than 0 but less than 0.5, the result is **+0**.
- If the argument is less than 0 but greater than or equal to -0.5, the result is **-0**.

Note that `Math.round(3.5)` returns 4, but `Math.round(-3.5)` returns -3.

The value of `Math.round(x)` is the same as the value of `Math.floor(x+0.5)`, except when  $x$  is **-0**; for this case `Math.round(x)` returns **-0**, but `Math.floor(x+0.5)` returns **+0**.

#### 15.8.2.16 sin(x)

Returns an implementation-dependent approximation to the sine of the argument. The argument is expressed in radians.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **+0**, the result is **+0**.
- If the argument is **-0**, the result is **-0**.
- If the argument is  $+\infty$  or  $-\infty$ , the result is **NaN**.

#### 15.8.2.17 sqrt(x)

Returns an implementation-dependent approximation to the square root of the argument.

- If the argument is **NaN**, the result is **NaN**.
- If the argument less than 0, the result is **NaN**.
- If the argument is **+0**, the result is **+0**.
- If the argument is **-0**, the result is **-0**.
- If the argument is  $+\infty$ , the result is  $+\infty$ .

#### 15.8.2.18 tan(x)

Returns an implementation-dependent approximation to the tangent of the argument. The argument is expressed in radians.

- If the argument is **NaN**, the result is **NaN**.
- If the argument is **+0**, the result is **+0**.
- If the argument is **-0**, the result is **-0**.
- If the argument is  $+\infty$  or  $-\infty$ , the result is **NaN**.

## 15.9 DATE OBJECTS

### 15.9.1 Overview of Date Objects

A Date object contains a number indicating a particular instant in time to within a millisecond. The number may also be **NaN**, indicating that the Date object does not represent a specific instant of time. The following sections define a number of functions for operating on time values. Note that, in every case, if any argument to such a function is **NaN**, the result will be **NaN**.

### 15.9.1.1 Time Range

Time is measured in ECMAScript in milliseconds since 01 January, 1970 UTC. Leap seconds are ignored. It is assumed that there are exactly 86,400,000 milliseconds per day. ECMAScript number values can represent all integers from  $iMin = -9,007,199,254,740,991$  to  $iMax = 9,007,199,254,740,991$ ; this range suffices to measure times to millisecond precision for any instant that is within approximately 285,616 years, either forward or backward, from 01 January, 1970 UTC.

The actual range of times supported by ECMAScript Date objects is slightly smaller: exactly – 100,000,000 days to 100,000,000 days measured relative to midnight at the beginning of 01 January, 1970 UTC. This gives a range of 8,640,000,000,000,000 milliseconds to either side of 01 January, 1970 UTC. This span easily covers all of recorded human history and a fair amount of unrecorded human history.

### 15.9.1.2 Day Number and Time within Day

A given time value  $t$  belongs to day number

$$\text{Day}(t) = \text{floor}(t / \text{msPerDay})$$

where the number of milliseconds per day is

$$\text{msPerDay} = 86400000$$

The remainder is called the time within the day:

$$\text{TimeWithinDay}(t) = t \text{ modulo } \text{msPerDay}$$

### 15.9.1.3 Year Number

ECMAScript uses an extrapolated Gregorian system to map a day number to a year number and to determine the month and date within that year. In this system, leap years are precisely those which are (divisible by 4) and ((not divisible by 100) or (divisible by 400)). The number of days in year number  $y$  is therefore defined by

$$\begin{aligned} \text{DaysInYear}(y) &= 365 && \text{if } (y \text{ modulo } 4) \neq 0 \\ &= 366 && \text{if } (y \text{ modulo } 4) = 0 \text{ and } (y \text{ modulo } 100) \neq 0 \\ &= 365 && \text{if } (y \text{ modulo } 100) = 0 \text{ and } (y \text{ modulo } 400) \neq 0 \\ &= 366 && \text{if } (y \text{ modulo } 400) = 0 \end{aligned}$$

Of course all non-leap years have 365 days with the usual number of days per month and leap years have an extra day in February. The day number of the first day of year  $y$  is given by:

$$\text{DayFromYear}(y) = 365(y-1970) + \text{floor}((y-1969)/4) - \text{floor}((y-1901)/100) + \text{floor}((y-1601)/400)$$

The time value of the start of a year is:

$$\text{TimeFromYear}(y) = \text{msPerDay} \cdot \text{DayFromYear}(y)$$

A time value determines a year by:

$$\text{YearFromTime}(t) = \text{the largest integer (closest to positive infinity) such that } \text{TimeFromYear}(y) \leq t$$

The leap-year function is 1 for a time within a leap year and otherwise is zero:

$$\begin{aligned} \text{InLeapYear}(t) &= 0 && \text{if } \text{DaysInYear}(\text{YearFromTime}(t)) = 365 \\ &= 1 && \text{if } \text{DaysInYear}(\text{YearFromTime}(t)) = 366 \end{aligned}$$

### 15.9.1.4 Month Number

Months are identified by an integer in the range 0 to 11, inclusive. The mapping from a time value  $t$  to a month number is defined by:

$$\begin{aligned} \text{MonthFromTime}(t) &= 0 && \text{if } 0 \leq \text{DayWithinYear}(t) < 31 \\ &= 1 && \text{if } 31 \leq \text{DayWithinYear}(t) < \\ &59 + \text{InLeapYear}(t) && \\ &= 2 && \text{if } 59 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < \\ &90 + \text{InLeapYear}(t) && \end{aligned}$$



$120 + \text{InLeapYear}(t)$	$= 3$	if $90 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$151 + \text{InLeapYear}(t)$	$= 4$	if $120 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$181 + \text{InLeapYear}(t)$	$= 5$	if $151 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$212 + \text{InLeapYear}(t)$	$= 6$	if $181 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$243 + \text{InLeapYear}(t)$	$= 7$	if $212 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$273 + \text{InLeapYear}(t)$	$= 8$	if $243 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$304 + \text{InLeapYear}(t)$	$= 9$	if $273 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$334 + \text{InLeapYear}(t)$	$= 10$	if $304 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$
$365 + \text{InLeapYear}(t)$	$= 11$	if $334 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) <$

where

$$\text{DayWithinYear}(t) = \text{Day}(t) - \text{DayFromYear}(\text{YearFromTime}(t))$$

A month value of 0 specifies January; 1 specifies February; 2 specifies March; 3 specifies April; 4 specifies May; 5 specifies June; 6 specifies July; 7 specifies August; 8 specifies September; 9 specifies October; 10 specifies November; and 11 specifies December. Note that  $\text{MonthFromTime}(0) = 0$ , corresponding to Thursday, 01 January, 1970.

#### 15.9.1.5 Date Number

A date number is identified by an integer in the range 1 through 31, inclusive. The mapping  $\text{DateFromTime}(t)$  from a time value  $t$  to a month number is defined by:

$\text{DateFromTime}(t) = \text{DayWithinYear}(t) + 1$	if $\text{MonthFromTime}(t) = 0$
$= \text{DayWithinYear}(t) - 30$	if $\text{MonthFromTime}(t) = 1$
$= \text{DayWithinYear}(t) - 58 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 2$
$= \text{DayWithinYear}(t) - 89 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 3$
$= \text{DayWithinYear}(t) - 119 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 4$
$= \text{DayWithinYear}(t) - 150 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 5$
$= \text{DayWithinYear}(t) - 180 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 6$
$= \text{DayWithinYear}(t) - 211 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 7$
$= \text{DayWithinYear}(t) - 242 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 8$
$= \text{DayWithinYear}(t) - 272 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 9$
$= \text{DayWithinYear}(t) - 303 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 10$
$= \text{DayWithinYear}(t) - 333 - \text{InLeapYear}(t)$	if $\text{MonthFromTime}(t) = 11$

#### 15.9.1.6 Week Day

The week day for a particular time value  $t$  is defined as

$$\text{WeekDay}(t) = (\text{Day}(t) + 4) \text{ modulo } 7$$

A weekday value of 0 specifies Sunday; 1 specifies Monday; 2 specifies Tuesday; 3 specifies Wednesday; 4 specifies Thursday; 5 specifies Friday; and 6 specifies Saturday. Note that  $\text{WeekDay}(0) = 4$ , corresponding to Thursday, 01 January, 1970.

#### 15.9.1.7 Local Time Zone Adjustment

An implementation of ECMAScript is expected to determine the local time zone adjustment by whatever means are available. The local time zone adjustment is a value  $\text{LocalTZA}$  measured in milliseconds which when added to UTC represents the local *standard* time. Daylight saving time is *not*

reflected by LocalTZA. The value LocalTZA does not vary with time but depends only on the geographic location.

### 15.9.1.8 Daylight Saving Time Adjustment

An implementation of ECMAScript is expected to determine the daylight saving time algorithm by whatever means are available. The algorithm to determine the daylight saving time adjustment  $\text{DaylightSavingTA}(t)$ , measured in milliseconds, must depend only on four things:

(1) the time since the beginning of the year

$$t - \text{TimeFromYear}(\text{YearFromTime}(t))$$

(2) whether it is a leap year

$$\text{InLeapYear}(t)$$

(3) the week day of the beginning of the year

$$\text{WeekDay}(\text{TimeFromYear}(\text{YearFromTime}(t)))$$

and (4) the geographic location.

The implementation of ECMAScript should not try to determine whether the exact time was subject to daylight saving time, but just whether daylight saving time would have been in effect if the current daylight saving time algorithm had been used at the time. This avoids complications such as taking into account the years that the USA observed daylight saving time year round.

If the underlying operating system provides functionality for determining daylight saving time, the implementation of ECMAScript is free to map the year in question to an equivalent year (same leap-year-ness and same starting week day for the year) for which the operating system provides daylight saving time information. The only restriction is that all equivalent years should produce the same result.

### 15.9.1.9 Local Time

Conversion from UTC to local time is defined by

$$\text{LocalTime}(t) = t + \text{LocalTZA} + \text{DaylightSavingTA}(t)$$

Conversion from local time to UTC is defined by

$$\text{UTC}(t) = t - \text{LocalTZA} - \text{DaylightSavingTA}(t - \text{LocalTZA})$$

Note that  $\text{UTC}(\text{LocalTime}(t))$  is not necessarily always equal to  $t$ .

### 15.9.1.10 Hours, Minutes, Second, and Milliseconds

The following functions are useful in decomposing time values:

$$\text{HourFromTime}(t) = \text{floor}(t / \text{msPerHour}) \text{ modulo } \text{HoursPerDay}$$

$$\text{MinFromTime}(t) = \text{floor}(t / \text{msPerMinute}) \text{ modulo } \text{MinutesPerHour}$$

$$\text{SecFromTime}(t) = \text{floor}(t / \text{msPerSecond}) \text{ modulo } \text{SecondsPerMinute}$$

$$\text{msFromTime}(t) = t \text{ modulo } \text{msPerSecond}$$

where

$$\text{HoursPerDay} = 24$$

$$\text{MinutesPerHour} = 60$$

$$\text{SecondsPerMinute} = 60$$

$$\text{msPerSecond} = 1000$$

$$\text{msPerMinute} = \text{msPerSecond} \cdot \text{SecondsPerMinute} = 60000$$

$$\text{msPerHour} = \text{msPerMinute} \cdot \text{MinutesPerHour} = 3600000$$

#### 15.9.1.11 MakeTime(hour, min, sec, ms)

The operator `MakeTime` calculates a number of milliseconds from its four arguments which must be ECMAScript number values. This operator functions as follows:

1. If *hour* is not finite or *min* is not finite or *sec* is not finite or *ms* is not finite, return **NaN**.
2. Call `ToInteger(hour)`.
3. Call `ToInteger(min)`.
4. Call `ToInteger(sec)`.
5. Call `ToInteger(ms)`.
6. Compute  $\text{Result}(2) \cdot \text{msPerHour} + \text{Result}(3) \cdot \text{msPerMinute} + \text{Result}(4) \cdot \text{msPerSecond} + \text{Result}(5)$ , performing the arithmetic according to IEEE 754 rules (that is, as if using the ECMAScript operators `*` and `+`).
7. Return `Result(6)`.

#### 15.9.1.12 MakeDay(year, month, date)

The operator `MakeDay` calculates a number of days from its three arguments which must be ECMAScript number values. This operator functions as follows:

1. If *year* is not finite or *month* is not finite or *date* is not finite, return **NaN**.
2. Call `ToInteger(year)`.
3. Call `ToInteger(month)`.
4. Call `ToInteger(date)`.
5. Compute  $\text{Result}(2) + \text{floor}(\text{Result}(3)/12)$ .
6. Compute  $\text{Result}(3) \bmod 12$ .
7. Find a value *t* such that `YearFromTime(t) == Result(5)` and `MonthFromTime(t) == Result(6)` and `DateFromTime(t) == 1`; but if this is not possible (because some argument is out of range), return **NaN**.
8. Compute  $\text{Day}(\text{Result}(7)) + \text{Result}(4) - 1$ .
9. Return `Result(8)`.

#### 15.9.1.13 MakeDate(day, time)

The operator `MakeDate` calculates a number of milliseconds from its two arguments which must be ECMAScript number values. This operator functions as follows:

1. If *day* is not finite or *time* is not finite, return **NaN**.
2. Compute  $\text{day} \cdot \text{msPerDay} + \text{time}$ .
3. Return `TimeClip(Result(2))`.

#### 15.9.1.14 TimeClip(time)

The operator `TimeClip` calculates a number of milliseconds from its argument which must be an ECMAScript number value. This operator functions as follows:

1. If *time* is not finite, return **NaN**.
2. If  $\text{abs}(\text{Result}(1)) > 8.64\text{e}15$  (that is,  $8.64 \cdot 10^{15}$ ), return **NaN**.
3. Return `ToInteger(Result(2))`.

### 15.9.2 The Date Constructor

When `Date` is called as part of a `new` expression, it is a constructor: it initializes the newly created object.

#### 15.9.2.1 new Date(year, month, date, hours, minutes, seconds, ms)

The `[[Class]]` property of the newly constructed object is set to `"Date"`.

The `[[Value]]` property of the newly constructed object is set as follows:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.

3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. Call `ToNumber(minutes)`.
6. Call `ToNumber(seconds)`.
7. Call `ToNumber(ms)`.
8. If  $0 \leq \text{ToInteger}(\text{Result}(1)) \leq 99$ , `Result(8)` is `1900+Result(1)`; otherwise, `Result(8)` is `Result(1)`.
9. Compute `MakeDay(Result(8), Result(2), Result(3))`.
10. Compute `MakeTime(Result(4), Result(5), Result(6), Result(7))`.
11. Compute `MakeDate(Result(9), Result(10))`.
12. Set the `[[Value]]` property of the newly constructed object to `UTC(Result(11))`.

### 15.9.2.2 `new Date(year, month, date, hours, minutes, seconds)`

The `[[Class]]` property of the newly constructed object is set to `"Date"`.

The `[[Value]]` property of the newly constructed object is set as follows:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. Call `ToNumber(minutes)`.
6. Call `ToNumber(seconds)`.
7. If  $0 \leq \text{ToInteger}(\text{Result}(1)) \leq 99$ , `Result(7)` is `1900+Result(1)`; otherwise, `Result(7)` is `Result(1)`.
8. Compute `MakeDay(Result(7), Result(2), Result(3))`.
9. Compute `MakeTime(Result(4), Result(5), Result(6), 0)`.
10. Compute `MakeDate(Result(8), Result(9))`.
11. Set the `[[Value]]` property of the newly constructed object to `UTC(Result(10))`.

### 15.9.2.3 `new Date(year, month, date, hours, minutes)`

The `[[Class]]` property of the newly constructed object is set to `"Date"`.

The `[[Value]]` property of the newly constructed object is set as follows:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. Call `ToNumber(minutes)`.
6. If  $0 \leq \text{ToInteger}(\text{Result}(1)) \leq 99$ , `Result(6)` is `1900+Result(1)`; otherwise, `Result(6)` is `Result(1)`.
7. Compute `MakeDay(Result(6), Result(2), Result(3))`.
8. Compute `MakeTime(Result(4), Result(5), 0, 0)`.
9. Compute `MakeDate(Result(7), Result(8))`.
10. Set the `[[Value]]` property of the newly constructed object to `UTC(Result(9))`.

### 15.9.2.4 `new Date(year, month, date, hours)`

The `[[Class]]` property of the newly constructed object is set to `"Date"`.

The `[[Value]]` property of the newly constructed object is set as follows:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. If  $0 \leq \text{ToInteger}(\text{Result}(1)) \leq 99$ , `Result(5)` is `1900+Result(1)`; otherwise, `Result(5)` is `Result(1)`.
6. Compute `MakeDay(Result(5), Result(2), Result(3))`.
7. Compute `MakeTime(Result(4), 0, 0, 0)`.
8. Compute `MakeDate(Result(6), Result(7))`.
9. Set the `[[Value]]` property of the newly constructed object to `UTC(Result(8))`.

### 15.9.2.5 new Date(year, month, day)

The `[[Class]]` property of the newly constructed object is set to `"Date"`.

The `[[Value]]` property of the newly constructed object is set as follows:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. If  $0 \leq \text{ToInteger}(\text{Result}(1)) \leq 99$ , `Result(4)` is `1900+Result(1)`; otherwise, `Result(4)` is `Result(1)`.
5. Compute `MakeDay(Result(4), Result(2), Result(3))`.
6. Compute `MakeDate(Result(5), 0)`.
7. Set the `[[Value]]` property of the newly constructed object to `UTC(Result(6))`.

### 15.9.2.6 new Date(year, month)

An attempt to call the `Date` constructor with two arguments generates a runtime error.

### 15.9.2.7 new Date(value)

The `[[Class]]` property of the newly constructed object is set to `"Date"`.

The `[[Value]]` property of the newly constructed object is set as follows:

1. Call `ToPrimitive(value)`.
2. If `Type(Result(1))` is `String`, then go to step 8.
3. Let  $V$  be `ToNumber(Result(1))`.
4. If  $V$  is `NaN`, go to step 7.
5. If  $\text{abs}(\text{Result}(2)) > 8.64 \times 10^{15}$  (that is,  $8.64 \cdot 10^{15}$ ), go to step 7.
6. Set the `[[Value]]` property of the newly constructed object to  $V$  and return.
7. Set the `[[Value]]` property of the newly constructed object to `NaN` and return.
8. Parse `Result(1)` as a date, in exactly the same manner as for the `parse` method (15.9.3.2); let  $V$  be the time value for this date.
9. Go to step 4.

### 15.9.2.8 new Date()

The `[[Class]]` property of the newly constructed object is set to `"Date"`.

The `[[Value]]` property of the newly constructed object is set to the current time (UTC).

## 15.9.3 Properties of the Date Constructor

The value of the internal `[[Prototype]]` property of the `Date` constructor is the Function prototype object.

Besides the internal `[[Call]]` and `[[Construct]]` properties and the `length` property (whose value is 7), the `Date` constructor has the following properties:

### 15.9.3.1 Date.prototype

The initial value of `Date.prototype` is the built-in `Date` prototype object.

This property shall have the attributes { DontEnum, ReadOnly }.

### 15.9.3.2 Date.parse(string)

The `parse` function applied to `ToString` operator to its argument and interprets the resulting string as a date; it returns a number, the UTC time value corresponding to the date. The string may be interpreted as a local time, a UTC time, or a time in some other time zone, depending on the contents of the string.

If  $x$  is any `Date` object within a particular implementation of ECMAScript, then all of the following expressions should produce the same numeric value in that implementation, if all the properties referenced have their initial values:

```
x.valueOf()  
Date.parse(x.toString())  
Date.parse(x.toGMTString())
```

However, the expression

```
Date.parse(x.toLocaleString())_
```

is not required to produce the same number value as the preceding three expressions and, in general, the value produced by `Date.parse` is implementation dependent when given any string value that could not be produced in that implementation by the `toString` or `toGMTString` method.

### 15.9.3.3 Date.UTC(year, month, date, hours, minutes, seconds, ms)

When the `UTC` function is called with seven arguments, the following steps are taken:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. Call `ToNumber(minutes)`.
6. Call `ToNumber(seconds)`.
7. Call `ToNumber(ms)`.
8. If  $0 \leq \text{Result}(1) \leq 99$ , `Result(8)` is  $1900 + \text{Result}(1)$ ; otherwise, `Result(8)` is `Result(1)`.
9. Compute `MakeDay(Result(8), Result(2), Result(3))`.
10. Compute `MakeTime(Result(4), Result(5), Result(6), Result(7))`.
11. Return `MakeDate(Result(9), Result(10))`.

The `UTC` function differs from the `Date` constructor in two ways: it returns a time value as a number, rather than creating a `Date` object, and it interprets the arguments in UTC rather than as local time.

### 15.9.3.4 Date.UTC(year, month, date, hours, minutes, seconds)

When the `UTC` function is called with six arguments, the following steps are taken:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. Call `ToNumber(minutes)`.
6. Call `ToNumber(seconds)`.
7. If  $0 \leq \text{Result}(1) \leq 99$ , `Result(7)` is  $1900 + \text{Result}(1)$ ; otherwise, `Result(7)` is `Result(1)`.
8. Compute `MakeDay(Result(7), Result(2), Result(3))`.
9. Compute `MakeTime(Result(4), Result(5), Result(6), 0)`.
10. Return `MakeDate(Result(8), Result(9))`.

The `UTC` function differs from the `Date` constructor in two ways: it returns a time value as a number, rather than creating a `Date` object, and it interprets the arguments in UTC rather than as local time.

### 15.9.3.5 Date.UTC(year, month, date, hours, minutes)

When the `UTC` function is called with five arguments, the following steps are taken:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. Call `ToNumber(minutes)`.
6. If  $0 \leq \text{Result}(1) \leq 99$ , `Result(6)` is  $1900 + \text{Result}(1)$ ; otherwise, `Result(6)` is `Result(1)`.
7. Compute `MakeDay(Result(6), Result(2), Result(3))`.
8. Compute `MakeTime(Result(4), Result(5), 0, 0)`.
9. Return `MakeDate(Result(7), Result(8))`.

The `UTC` function differs from the `Date` constructor in two ways: it returns a time value as a number, rather than creating a `Date` object, and it interprets the arguments in UTC rather than as local time.

### 15.9.3.6 Date.UTC(year, month, date, hours)

When the `UTC` function is called with four arguments, the following steps are taken:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. Call `ToNumber(hours)`.
5. If  $0 \leq \text{Result}(1) \leq 99$ , `Result(5)` is  $1900 + \text{Result}(1)$ ; otherwise, `Result(5)` is `Result(1)`.
6. Compute `MakeDay(Result(5), Result(2), Result(3))`.
7. Compute `MakeTime(Result(4), 0, 0, 0)`.
8. Return `MakeDate(Result(6), Result(7))`.

The UTC function differs from the Date constructor in two ways: it returns a time value as a number, rather than creating a Date object, and it interprets the arguments in UTC rather than as local time.

### 15.9.3.7 Date.UTC(year, month, date)

When the UTC function is called with three arguments, the following steps are taken:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. Call `ToNumber(date)`.
4. If  $0 \leq \text{Result}(1) \leq 99$ , `Result(4)` is  $1900 + \text{Result}(1)$ ; otherwise, `Result(4)` is `Result(1)`.
5. Compute `MakeDay(Result(4), Result(2), Result(3))`.
6. Return `MakeDate(Result(5), 0)`.

The UTC function differs from the Date constructor in two ways: it returns a time value as a number, rather than creating a Date object, and it interprets the arguments in UTC rather than as local time.

### 15.9.3.8 Date.UTC(year, month)

An attempt to call the UTC function with two arguments generates a runtime error.

### 15.9.3.9 Date.UTC(year)

An attempt to call the UTC function with one argument generates a runtime error.

### 15.9.3.10 Date.UTC()

An attempt to call the UTC function with no arguments generates a runtime error.

## 15.9.4 Properties of the Date Prototype Object

In following descriptions of functions that are properties of the Date prototype object, the phrase “this Date object” refers to the object that is the `this` value for the invocation of the function; it is an error if `this` does not refer to an object for which the value of the internal `[[Class]]` property is `not Date`. Also, the phrase “this time value” refers to the number value for the time represented by this Date object, that is, the value of the internal `[[Value]]` property of this Date object.

### 15.9.4.1 Date.prototype.constructor

The initial value of `Date.prototype.constructor` is the built-in `Date` constructor.

### 15.9.4.2 Date.prototype.toString()

This function returns a string value. The contents of the string are implementation dependent, but are intended to represent the Date in a convenient, human-readable form in the current time zone. Different time values must result in different string values from this function.

The `toString` function is not generic; it generates a runtime error if its `this` value is not a Date object. Therefore it cannot be transferred to other kinds of objects for use as a method.

### 15.9.4.3 Date.prototype.valueOf()

The `valueOf` function returns a number, which is this time value.

The `valueOf` function is not generic; it generates a runtime error if its `this` value is not a Date object. Therefore it cannot be transferred to other kinds of objects for use as a method.

#### 15.9.4.4 Date.prototype.getTime()

1. If the **this** value is not an object whose [[Class]] property is "**Date**", generate a runtime error.
2. Return this time value.

#### 15.9.4.5 Date.prototype.getYear()

This function is specified here for backwards compatibility only. The function **getFullYear** is much to be preferred for nearly all purposes, because it avoids the “year 2000 problem.”

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return YearFromTime(LocalTime(*t*)) – 1900.

#### 15.9.4.6 Date.prototype.getFullYear()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return YearFromTime(LocalTime(*t*)).

#### 15.9.4.7 Date.prototype.getUTCFullYear()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return YearFromTime(*t*).

#### 15.9.4.8 Date.prototype.getMonth()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return MonthFromTime(LocalTime(*t*)).

#### 15.9.4.9 Date.prototype.getUTCMonth()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return MonthFromTime(*t*).

#### 15.9.4.10 Date.prototype.getDate()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return DateFromTime(LocalTime(*t*)).

#### 15.9.4.11 Date.prototype.getUTCDate()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return DateFromTime(*t*).

#### 15.9.4.12 Date.prototype.getDay()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return WeekDay(LocalTime(*t*)).

#### 15.9.4.13 Date.prototype.getUTCDay()

1. Let *t* be this time value.
2. If *t* is **NaN**, return **NaN**.
3. Return WeekDay(*t*).



#### 15.9.4.14 Date.prototype.getHours()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return HourFromTime(LocalTime( $t$ )).

#### 15.9.4.15 Date.prototype.getUTCHours()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return HourFromTime( $t$ ).

#### 15.9.4.16 Date.prototype.getMinutes()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return MinFromTime(LocalTime( $t$ )).

#### 15.9.4.17 Date.prototype.getUTCMinutes()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return MinFromTime( $t$ ).

#### 15.9.4.18 Date.prototype.getSeconds()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return SecFromTime(LocalTime( $t$ )).

#### 15.9.4.19 Date.prototype.getUTCSeconds()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return SecFromTime( $t$ ).

#### 15.9.4.20 Date.prototype.getMilliseconds()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return msFromTime(LocalTime( $t$ )).

#### 15.9.4.21 Date.prototype.getUTCMilliseconds()

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return msFromTime( $t$ ).

#### 15.9.4.22 Date.prototype.getTimezoneOffset()

Returns the difference between local time and UTC time in minutes.

1. Let  $t$  be this time value.
2. If  $t$  is **NaN**, return **NaN**.
3. Return  $(t - \text{LocalTime}(t)) / \text{msPerMinute}$ .

#### 15.9.4.23 Date.prototype.setTime(time)

1. Call ToNumber( $time$ ).
2. Call TimeClip(Result(1)).
3. Set the [[Value]] property of the **this** value to Result(2).
4. Return the value of the [[Value]] property of the **this** value.
- 5.

#### 15.9.4.24 Date.prototype.setMilliseconds(ms)

1. Let  $t$  be the result of LocalTime(this time value).
2. Call ToNumber( $ms$ ).
3. Compute MakeTime(HourFromTime( $t$ ), MinFromTime( $t$ ), SecFromTime( $t$ ), Result(2)).
4. Compute UTC(MakeDate(Day( $t$ ), Result(3))).
5. Set the [[Value]] property of the **this** value to Result(4).
6. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.25 Date.prototype.setUTCMilliseconds(ms)

1. Let  $t$  be this time value.
2. Call ToNumber( $ms$ ).
3. Compute MakeTime(HourFromTime( $t$ ), MinFromTime( $t$ ), SecFromTime( $t$ ), Result(2)).
4. Compute MakeDate(Day( $t$ ), Result(3)).
5. Set the [[Value]] property of the **this** value to Result(4).
6. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.26 Date.prototype.setSeconds(sec [, ms ] )

If  $ms$  is not specified, this behaves as if  $ms$  were specified with the value getMilliseconds( ).

1. Let  $t$  be the result of LocalTime(this time value).
2. Call ToNumber( $sec$ ).
3. If  $ms$  is not specified, compute msFromTime( $t$ ); otherwise, call ToNumber( $ms$ ).
4. Compute MakeTime(HourFromTime( $t$ ), MinFromTime( $t$ ), Result(2), Result(3)).
5. Compute UTC(MakeDate(Day( $t$ ), Result(4))).
6. Set the [[Value]] property of the **this** value to Result(5).
7. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.27 Date.prototype.setUTCSeconds(sec [, ms ] )

If  $ms$  is not specified, this behaves as if  $ms$  were specified with the value getUTCMilliseconds( ).

1. Let  $t$  be this time value.
2. Call ToNumber( $sec$ ).
3. If  $ms$  is not specified, compute msFromTime( $t$ ); otherwise, call ToNumber( $ms$ ).
4. Compute MakeTime(HourFromTime( $t$ ), MinFromTime( $t$ ), Result(2), Result(3)).
5. Compute MakeDate(Day( $t$ ), Result(4)).
6. Set the [[Value]] property of the **this** value to Result(5).
7. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.28 Date.prototype.setMinutes(min [, sec [, ms ] ] )

If  $sec$  is not specified, this behaves as if  $sec$  were specified with the value getSeconds( ).

If  $ms$  is not specified, this behaves as if  $ms$  were specified with the value getMilliseconds( ).

1. Let  $t$  be the result of LocalTime(this time value).
2. Call ToNumber( $min$ ).
3. If  $sec$  is not specified, compute SecFromTime( $t$ ); otherwise, call ToNumber( $sec$ ).
4. If  $ms$  is not specified, compute msFromTime( $t$ ); otherwise, call ToNumber( $ms$ ).
5. Compute MakeTime(HourFromTime( $t$ ), Result(2), Result(3), Result(4)).
6. Compute UTC(MakeDate(Day( $t$ ), Result(5))).
7. Set the [[Value]] property of the **this** value to Result(6).
8. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.29 Date.prototype.setUTCMinutes(min [, sec [, ms ] ] )

If  $sec$  is not specified, this behaves as if  $sec$  were specified with the value getUTCSeconds( ).

If  $ms$  is not specified, this behaves as if  $ms$  were specified with the value getUTCMilliseconds( ).

1. Let  $t$  be this time value.

2. Call `ToNumber(min)`.
3. If *sec* is not specified, compute `SecFromTime(t)`; otherwise, call `ToNumber(sec)`.
4. If *ms* is not specified, compute `msFromTime(t)`; otherwise, call `ToNumber(ms)`.
5. Compute `MakeTime(HourFromTime(t), Result(2), Result(3), Result(4))`.
6. Compute `MakeDate(Day(t), Result(5))`.
7. Set the `[[Value]]` property of the `this` value to `Result(6)`.
8. Return the value of the `[[Value]]` property of the `this` value.

#### 15.9.4.30 `Date.prototype.setHours(hour [, min [, sec [, ms ]])`

If *min* is not specified, this behaves as if *min* were specified with the value `getMinutes()`.

If *sec* is not specified, this behaves as if *sec* were specified with the value `getSeconds()`.

If *ms* is not specified, this behaves as if *ms* were specified with the value `getMilliseconds()`.

1. Let *t* be the result of `LocalTime(this time value)`.
2. Call `ToNumber(hour)`.
3. If *min* is not specified, compute `MinFromTime(t)`; otherwise, call `ToNumber(min)`.
4. If *sec* is not specified, compute `SecFromTime(t)`; otherwise, call `ToNumber(sec)`.
5. If *ms* is not specified, compute `msFromTime(t)`; otherwise, call `ToNumber(ms)`.
6. Compute `MakeTime(Result(2), Result(3), Result(4), Result(5))`.
7. Compute `UTC(MakeDate(Day(t), Result(6)))`.
8. Set the `[[Value]]` property of the `this` value to `Result(7)`.
9. Return the value of the `[[Value]]` property of the `this` value.

#### 15.9.4.31 `Date.prototype.setUTCHours(hour [, min [, sec [, ms ]])`

If *min* is not specified, this behaves as if *min* were specified with the value `getUTCMinutes()`.

If *sec* is not specified, this behaves as if *sec* were specified with the value `getUTCSeconds()`.

If *ms* is not specified, this behaves as if *ms* were specified with the value `getUTCMilliseconds()`.

1. Let *t* be this time value.
2. Call `ToNumber(hour)`.
3. If *min* is not specified, compute `MinFromTime(t)`; otherwise, call `ToNumber(min)`.
4. If *sec* is not specified, compute `SecFromTime(t)`; otherwise, call `ToNumber(sec)`.
5. If *ms* is not specified, compute `msFromTime(t)`; otherwise, call `ToNumber(ms)`.
6. Compute `MakeTime(Result(2), Result(3), Result(4), Result(5))`.
7. Compute `MakeDate(Day(t), Result(6))`.
8. Set the `[[Value]]` property of the `this` value to `Result(7)`.
9. Return the value of the `[[Value]]` property of the `this` value.

#### 15.9.4.32 `Date.prototype.setDate(date)`

1. Let *t* be the result of `LocalTime(this time value)`.
2. Call `ToNumber(date)`.
3. Compute `MakeDay(YearFromTime(t), MonthFromTime(t), Result(2))`.
4. Compute `UTC(MakeDate(Result(3), TimeWithinDay(t)))`.
5. Set the `[[Value]]` property of the `this` value to `Result(4)`.
6. Return the value of the `[[Value]]` property of the `this` value.

#### 15.9.4.33 `Date.prototype.setUTCDate(date)`

1. Let *t* be this time value.
2. Call `ToNumber(date)`.
3. Compute `MakeDay(YearFromTime(t), MonthFromTime(t), Result(2))`.
4. Compute `MakeDate(Result(3), TimeWithinDay(t))`.
5. Set the `[[Value]]` property of the `this` value to `Result(4)`.
6. Return the value of the `[[Value]]` property of the `this` value.

#### 15.9.4.34 Date.prototype.setMonth(mon [, date ] )

If *date* is not specified, this behaves as if *date* were specified with the value getDate( ).

1. Let *t* be the result of LocalTime(this time value).
2. Call ToNumber(*date*).
3. If *date* is not specified, compute DateFromTime(*t*); otherwise, call ToNumber(*date*).
4. Compute MakeDay(YearFromTime(*t*), Result(2), Result(3)).
5. Compute UTC(MakeDate(Result(4), TimeWithinDay(*t*))).
6. Set the [[Value]] property of the **this** value to Result(5).
7. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.35 Date.prototype.setUTCMonth(mon [, date ] )

If *date* is not specified, this behaves as if *date* were specified with the value getUTCDate( ).

1. Let *t* be this time value.
2. Call ToNumber(*date*).
3. If *date* is not specified, compute DateFromTime(*t*); otherwise, call ToNumber(*date*).
4. Compute MakeDay(YearFromTime(*t*), Result(2), Result(3)).
5. Compute MakeDate(Result(4), TimeWithinDay(*t*)).
6. Set the [[Value]] property of the **this** value to Result(5).
7. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.36 Date.prototype.setFullYear(year [, mon [, date ] ] )

If *mon* is not specified, this behaves as if *mon* were specified with the value getMonth( ).

If *date* is not specified, this behaves as if *date* were specified with the value getDate( ).

1. Let *t* be the result of LocalTime(this time value).
2. Call ToNumber(*year*).
3. If *mon* is not specified, compute MonthFromTime(*t*); otherwise, call ToNumber(*mon*).
4. If *date* is not specified, compute DateFromTime(*t*); otherwise, call ToNumber(*date*).
5. Compute MakeDay(Result(2), Result(3), Result(4)).
6. Compute UTC(MakeDate(Result(5), TimeWithinDay(*t*))).
7. Set the [[Value]] property of the **this** value to Result(6).
8. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.37 Date.prototype.setUTCFullYear(year [, mon [, date ] ] )

If *mon* is not specified, this behaves as if *mon* were specified with the value getUTCMonth( ).

If *date* is not specified, this behaves as if *date* were specified with the value getUTCDate( ).

1. Let *t* be this time value.
2. Call ToNumber(*year*).
3. If *mon* is not specified, compute MonthFromTime(*t*); otherwise, call ToNumber(*mon*).
4. If *date* is not specified, compute DateFromTime(*t*); otherwise, call ToNumber(*date*).
5. Compute MakeDay(Result(2), Result(3), Result(4)).
6. Compute MakeDate(Result(5), TimeWithinDay(*t*)).
7. Set the [[Value]] property of the **this** value to Result(6).
8. Return the value of the [[Value]] property of the **this** value.

#### 15.9.4.38 Date.prototype.setYear(year)

This function is specified here for backwards compatibility only. The function **setFullYear** is much to be preferred for nearly all purposes, because it avoids the “year 2000 problem.”

1. Let *t* be the result of LocalTime(this time value).
2. Call ToNumber(*year*).
3. If Result(2) is NaN, set the [[Value]] property of the **this** value to NaN and return NaN.
4. Call ToInteger(Result(1)).
5. If  $0 \leq \text{Result}(3) \leq 99$ , then Result(4) is Result(3) + 1900. Otherwise, Result(4) is Result(3).

6. Compute `MakeDay(Result(5), MonthFromTime(t), DateFromTime(t))`.
7. Compute `UTC(MakeDate(Result(6), TimeWithinDay(t)))`.
8. Set the `[[Value]]` property of the `this` value to `Result(7)`.
9. Return the value of the `[[Value]]` property of the `this` value.

#### 15.9.4.39 `Date.prototype.toLocaleString()`

This function returns a string value. The contents of the string are implementation dependent, but are intended to represent the Date in a convenient, human-readable form appropriate to the geographic or cultural locale. Different time values must result in different string values from this function.

#### 15.9.4.40 `Date.prototype.toUTCString()`

This function returns a string value. The contents of the string are implementation dependent, but are intended to represent the Date in a convenient, human-readable form in UTC. Different time values must result in different string values from this function.

#### 15.9.4.41 `Date.prototype.toGMTString()`

The function object that is the initial value of `Date.prototype.toGMTString` is the same function object that is the initial value of `Date.prototype.toUTCString`. The `toGMTString` property is provided principally for compatibility with old code. It is recommended that the `toUTCString` property be used in new ECMAScript code.

### 15.9.5 Properties of Date Instances

Date instances have no special properties beyond those inherited from the Date prototype object.

## 16 ERRORS

This specification specifies the last possible moment an error occurs. A given implementation may generate errors sooner (e.g. at compile-time). Doing so may cause differences in behavior among implementations. Notably, if runtime errors become catchable in future versions, a given error would not be catchable if an implementation generates the error at compile-time rather than runtime.

An ECMAScript compiler should detect errors at compile time in all code presented to it, even code that detailed analysis might prove to be “dead” (never executed). A programmer should not rely on the trick of placing code within an `if (false)` statement, for example, to try to suppress compile-time error detection.

Issue: If a compiler can prove that a construct cannot execute without error under any circumstances, then it may issue a compile-time error even though the construct might not be executed at all?

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