ECMA
Standardizing Information and Communication Systems

ECMAScript 3.1 Language Specification - DRAFT

07 November 2008
Brief History

This ECMA Standard is based on several originating technologies, the most well known being JavaScript (Netscape) and JScript (Microsoft). The language was invented by Brendan Eich at Netscape and first appeared in that company’s Navigator 2.0 browser. It has appeared in all subsequent browsers from Netscape and in all browsers from Microsoft starting with Internet Explorer 3.0.

The development of this Standard started in November 1996. The first edition of this ECMA Standard was adopted by the ECMA General Assembly of June 1997.

That ECMA Standard was submitted to ISO/IEC JTC 1 for adoption under the fast-track procedure, and approved as international standard ISO/IEC 16262, in April 1998. The ECMA General Assembly of June 1998 approved the second edition of ECMA-262 to keep it fully aligned with ISO/IEC 16262. Changes between the first and the second edition are editorial in nature.

The third edition of the Standard includes powerful regular expressions, better string handling, new control statements, try/catch exception handling, tighter definition of errors, formatting for numeric output and minor changes in anticipation of forthcoming internationalisation facilities and future language growth. The language documented by the third edition has come to be known as ECMAScript 3 or ES3.

Work on the language is not complete. The technical committee is working on significant enhancements, including mechanisms for scripts to be created and used across the Internet, and tighter coordination with other standards bodies such as groups within the World Wide Web Consortium and the Wireless Application Protocol Forum.
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Additions and Changes in Edition 3.1 which Introduce Incompatibilities with Edition 3. 211
1 Scope
This Standard defines the ECMAScript scripting language.

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

A conforming implementation of this International standard shall interpret characters in conformance with the Unicode Standard, Version 3.0 or later, and ISO/IEC 10646-1 with either UCS-2 or UTF-16 as the adopted encoding form, implementation level 3. If the adopted ISO/IEC 10646-1 subset is not otherwise specified, it is presumed to be the BMP subset, collection 300. If the adopted encoding form is not otherwise specified, it presumed to be the UTF-16 encoding form.

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 and regular expression 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 7.5.3 of this specification.

3 References

4 Overview
This section contains a non-normative overview of the ECMAScript language.

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 behaviour 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, customise, 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. To accommodate non-professional programmers, some aspects of the language are defined to be tolerant of programmer mistakes. However, such tolerance can easily result in programs containing undiscovered errors that professional programmers would wish to discover and correct. To facilitate such error detection script can be explicitly declared to use a “strict” variant of the full ECMAScript language that provides enhanced error detection as well.

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.

Some of the facilities of ECMAScript are similar to those used in other programming languages; in particular Java™, Self, and Scheme as described in:


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 customised 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 zero or more attributes that determine how each property can be used—for example, when the Writable attribute for a property is set to false, any attempt by executed ECMAScript code to change the value of the property fails. 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 that 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, the Date object, the RegExp object, the JSON object, the Decimal object, and the Error objects Error, EvalError, RangeError, ReferenceError, SyntaxError, TypeError and URIError.

ECMAScript also defines a set of built-in operators. 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 defined functions are not required to have their declarations appear textually before calls to them.

4.2.1 Objects
ECMAScript does not contain 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 initialises all or part of them by assigning initial values to their properties. All constructors are objects, but not all
objects are constructors. Each constructor has a property named `prototype` that 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 object created by a constructor has an implicit reference (called the object’s prototype) to the value of its constructor’s `prototype` property. 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 behaviour. In ECMAScript, the state and methods are carried by objects, and structure, behaviour, 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 illustrates this:

![Diagram of object hierarchy]

CF is a constructor (and also an object). Five objects have been created by using `new` expressions: `cf1`, `cf2`, `cf3`, `cf4`, and `cf5`. Each of these objects contains properties named `q1` and `q2`. The dashed lines represent the implicit prototype relationship; so, for example, `cf3`’s prototype is `CFp`. The constructor, `CF`, has two properties itself, named `p1` and `p2`, which are not visible to `cf1`, `cf2`, `cf3`, `cf4`, or `cf5`. The property named `CFP1` in `CFp` is shared by `cf1`, `cf2`, `cf3`, `cf4`, and `cf5` (but not by `CF`), as are any properties found in `CFp`’s implicit prototype chain that are not named `q1`, `q2`, or `CFP1`. Notice that there is no implicit prototype link between `CF` and `CFp`.

Unlike class-based object languages, properties can be added to objects dynamically by assigning values to them. That is, constructors are not required to name or assign values to all or any of the constructed object’s properties. In the above diagram, one could add a new shared property for `cf1`, `cf2`, `cf3`, `cf4`, and `cf5` by assigning a new value to the property in `CFp`.

### 4.2.2 The Strict variant of ECMAScript

The ECMAScript Language recognizes the possibility that some users of the language may wish to restrict their usage of some features available in the language. They might do so in the interests of security, to avoid what they consider to be error prone features, to get better error checking, or for other reasons of their choosing. In support of this possibility, ECMAScript defines a strict variant of the
The strict subset of the language excludes some specific syntactic and semantic features of the non-strict ECMAScript language and modifies the detailed semantics of some features. The strict variant also specifies additional error conditions that must be reported by throwing error exceptions in situations that are not specified as errors by the non-strict form of the language.

The strict variant of ECMAScript is commonly referred to as the strict mode of the language. Strict mode selection and use of the strict mode syntax and semantics of ECMAScript is explicitly made at the level of individual ECMAScript code units. Because strict mode is selected at the level of a syntactic Program unit, strict mode only imposes restrictions that have local effect within such a Program unit. Strict mode does not restrict or modify any aspect of the ECMAScript semantics that must operate consistently across multiple Program units. A complete ECMAScript program may be composed for both strict mode and non-strict mode ECMAScript Program units. In this case, strict mode only applies when actually executing code that is defined within a strict mode Program unit.

In order to conform to this specification, an ECMAScript implementation must implement both the full unrestricted ECMAScript language and the strict mode variant of the ECMAScript language as defined by this specification. In addition, an implementation must support the combination of unrestricted and strict mode Program units into a single composite program.

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.

4.3.2 Primitive Value

A primitive value is a member of one of the types Undefined, Null, Boolean, Number, Decimal, or String. A primitive value is a datum that 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 a collection of properties.

4.3.4 Constructor

A constructor is a Function object that creates and initialises objects. The value of a constructor’s "prototype" property is a prototype object that is used to implement inheritance and shared properties.

4.3.5 Prototype

A prototype is an object used to implement structure, state, and behaviour inheritance in ECMAScript. When a constructor creates an object, that object implicitly references the constructor’s "prototype" property, for the purpose of resolving property references. The constructor’s "prototype" property 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, which is present at the start of the execution of an ECMAScript program. Standard built-in objects are defined in this specification, and an ECMAScript implementation may specify and define others. Every built-in object is a native object. A built-in constructor is a built-in object that is also a constructor.

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 Value
The *undefined value* 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 Value
The *null value* is a primitive value that represents the null, empty, or non-existent 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 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 built-in Boolean object. 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 that is the boolean. A Boolean object can be coerced to a boolean value.

4.3.16 String Value
A *string value* is a member of the type String and is a finite ordered sequence of zero or more 16-bit unsigned integer values.

**NOTE**
Although each value usually represents a single 16-bit unit of UTF-16 text, the language does not place any restrictions or requirements on the values except that they be 16-bit unsigned integers.

4.3.17 String Type
The type String is the set of all string values.

4.3.18 String Object
A *String object* is a member of the type Object and is an instance of the built-in String object. 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 that is the string. A String object can be coerced to a string value by calling the String constructor as a function (15.5.1).

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 represents the double-precision 64-bit format IEEE 754 values including the special “Not-a-Number” (NaN) values, 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 built-in Number object. 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 that is the number. A Number object can be coerced to a number value by calling the Number constructor as a function (15.7.1).

4.3.22 Infinity
The primitive value *Infinity* represents the positive infinite number value. This value is a member of the Number type.
4.3.23 NaN
The primitive value NaN represents the set of IEEE Standard “Not-a-Number” values. This value is a member of the Number type.

4.3.24 Function
A function is a member of the type Object that may be invoked as a subroutine. In addition to its named properties, a function contains executable code and state that determine how it behaves when invoked. A function’s code may or may not be written in ECMAScript.

4.3.25 Internal Function
An internal function is a function that is a built-in object 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. Internal functions do not necessarily contain executable code defined by the ECMAScript grammar.

4.3.26 Property
A property is an association between a name and a value. Depending upon the form of the property the value may be represented either directly as a data value (a primitive value, an object, or a function) or indirectly by a pair of accessor functions.

4.3.27 Method
A method is a function that is the value of a property.

4.3.28 Attribute
An attribute is an internal value that defines some characteristic of a property.

4.3.29 Own Property
An own property of an object is a property that is directly present on that object.

4.3.30 Inherited Property
An inherited property is a property of an object that is not one of its own properties but is a property (either own or inherited) of the object’s prototype.

4.3.31 Built-in Method
A built-in method is any method supplied by an ECMAScript implementation, independent of the host environment. Standard built-in methods are defined in this specification, and an ECMAScript implementation may specify and define others. A built-in method is an internal function.

4.3.32 Decimal Value
A decimal value is a member of the type Decimal and is a direct representation of a number.

4.3.33 Decimal Type
The type Decimal is a set of values representing numbers. In ECMAScript, the set of values represents the quad-precision 128-bit format IEEE 754-2008 values including the special “Not-a-Number” (NaN) values, positive infinities, and negative infinities.

4.3.34 Decimal Object
A Decimal object is a member of the type Object and is an instance of the built-in Number object. That is, a Decimal object is created by using the Decimal constructor in a new expression, supplying a decimal value as an argument. The resulting object has an implicit (unnamed) property that is the decimal value. A Decimal object can be coerced to a decimal value by calling the Decimal constructor as a function (15.7.1).
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 zero 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 and RegExp Grammars

A lexical grammar for ECMAScript is given in clause 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 InputElementDiv or InputElementRegExp, 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 (7.9). Simple white space and single-line comments are discarded and do not appear in the stream of input elements for the syntactic grammar. A MultiLineComment (that is, a comment of the form ―/*…*/‖ regardless of whether it spans more than one line) is likewise simply discarded if it contains no line terminator; but if a MultiLineComment 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.

A RegExp grammar for ECMAScript is given in 15.10. This grammar also has as its terminal symbols the characters of the Unicode character set. It defines a set of productions, starting from the goal symbol Pattern, that describe how sequences of Unicode characters are translated into regular expression patterns.

Productions of the lexical and RegExp grammars are distinguished by having two colons ―::‖ as separating punctuation. The lexical and RegExp grammars share some productions.

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 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 clauses 11, 12, 13 and 14. This grammar has ECMAScript tokens defined by the lexical grammar as its terminal symbols (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 sections 11, 12, 13 and 14 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 line terminator characters). Furthermore, certain token sequences that are described by the grammar are not considered acceptable if a terminator character appears in certain “awkward” places.

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. All nonterminal characters specified in this way are to be understood as the appropriate Unicode character from the ASCII range, as opposed to any similar-looking characters from other Unicode ranges.

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:

```
WhileStatement: while (Expression) Statement
```

states that the nonterminal `WhileStatement` represents the token `while`, 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 , 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, 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 Initialiseropt
VariableDeclaration: Identifier Initialiser
```

is a convenient abbreviation for:

```
VariableDeclaration: Identifier Initialiser , Initialiser
VariableDeclaration: Identifier Initialiser
```

and that:

```
IterationStatement: for ( Expressionopt ; Expressionopt ; Expressionopt ) Statement
IterationStatement: for ( ; Expressionopt ; Expressionopt ) Statement
IterationStatement: for ( Expressionopt ; Expressionopt ) Statement
```

which in turn is an abbreviation for:

```
for ( Expressionopt ; Expressionopt ) Statement
```

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

which in turn is an abbreviation for:

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

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

If the phrase “[empty]” appears as the right-hand side of a production, it indicates that the production's right-hand side contains no terminals or nonterminals.

If the phrase “[lookahead set]” appears in the right-hand side of a production, it indicates that the production may not be used if the immediately following input terminal is a member of the given set. The set can be written as a list of terminals enclosed in curly braces. For convenience, the set can also be written as a nonterminal, in which case it represents the set of all terminals to which that nonterminal could expand. For example, given the definitions

DecimalDigit :: one of
0 1 2 3 4 5 6 7 8 9

DecimalDigits ::
DecimalDigit
DecimalDigits DecimalDigit

the definition

LookaheadExample ::
[lookahead \{1,3,5,7,9\}] DecimalDigits
DecimalDigit [lookahead DecimalDigit]

matches either the letter n followed by one or more decimal digits the first of which is even, or a decimal digit not followed by another decimal digit.

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 ;

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

which is merely a convenient abbreviation for:

NonZeroDigit :: 1 2 3 4 5 6 7 8 9

When an alternative in a production of the lexical grammar or the numeric string grammar appears to be
a multi-character 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
The specification often uses a numbered list to specify steps in an algorithm. These algorithms are used to
clarify semantics. In practice, there may be more efficient algorithms available to implement a given
feature.

When an algorithm is to produce a value as a result, the directive “return x” is used to indicate that the
result of the algorithm is the value of x and that the algorithm should terminate. The notation Result(n) is
used as shorthand for “the result of step n”. Type(x) is used as shorthand for “the type of x”.

For clarity of expression, algorithm steps may be subdivided into sequential substeps. Substeps are indented
and may themselves be further divided into indented substeps. Outline numbering conventions are used to
identify substeps with the first level of substeps labeled with lower case alphabetic characters and the
second level of substeps labelled with lower case roman numerals. If more than three levels are required
these rules repeat with the fourth level using numeric labels. For example:

1. Top-level step
   a. Substep.
   b. Substep
      i. Subsubstep.
      ii. Subsubstep.
        1. Subsubsubstep
           a. Subsubsubsubstep

A step or substep may be written as a predicate that conditions its substeps. In this case, the substeps are
only applied if the predicate is true. If a step or substep begins with the word “else” it is a predicate that is
the negation of the preceding predicate step at the same level. If “else” is immediately followed by a
parenthesized step or substep label then it is a predicate that is the negation of that labelled predicate.
A step may specify the iterative application of its substeps. Mathematical operations such as addition, subtraction, negation, multiplication, division, and the mathematical functions defined later in this section should always be understood as computing exact mathematical results on mathematical real numbers, which do not include infinities and do not include a negative zero that is distinguished from positive zero. Algorithms in this standard that model floating-point arithmetic include explicit steps, where necessary, to handle infinities and signed zero and to perform rounding. If a mathematical operation or function is applied to a floating-point number, it should be understood as being applied to the exact mathematical value represented by that floating-point number; such a floating-point number must be finite, and if it is +0 or –0 then the corresponding mathematical value is simply 0.

The mathematical function 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 sign(x) yields 1 if x is positive and –1 if x is negative. The sign function is not used in this standard for cases when x is zero.

The notation “x modulo y” (y must be finite and nonzero) computes a value k of the same sign as y (or zero) such that abs(k) < abs(y) and x = k + q * y for some integer q.

The mathematical function floor(x) yields the largest integer (closest to positive infinity) that is not larger than x.

NOTE floor(x) = x – (x modulo 1).

If an algorithm is defined to “throw an exception”, execution of the algorithm is terminated and no result is returned. The calling algorithms are also terminated, until an algorithm step is reached that explicitly deals with the exception, using terminology such as “If an exception was thrown...”. Once such an algorithm step has been encountered the exception is no longer considered to have occurred.

6. Source Text

ECMAScript source text is represented as a sequence of characters in the Unicode character encoding, version 3.0 or later, using the UTF-16 transformation format. The text is expected to have been normalised to Unicode Normalised Form C (canonical composition), as described in Unicode Technical Report #15. Conforming ECMAScript implementations are not required to perform any normalisation of text, or behave as though they were performing normalisation of text, themselves.

SourceCharacter :: any Unicode character

Throughout the rest of this document, the phrase “code point” and the word “character” will be used to refer to a 16-bit unsigned value used to represent a single 16-bit unit of UTF-16 text. The phrase “Unicode character” will be used to refer to the abstract linguistic or typographical unit represented by a single Unicode scalar value (which may be longer than 16 bits and thus may be represented by more than one code point). This only refers to entities represented by single Unicode scalar values: the components of a combining character sequence are still individual “Unicode characters,” even though a user might think of the whole sequence as a single character.

In string literals, regular expression literals and identifiers, any character (code point) may also be expressed as a Unicode escape sequence consisting of six 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 or regular expression literal, the Unicode escape sequence contributes one character to the value of the literal. Within an identifier, the escape sequence contributes one character to the identifier.

NOTE 1

Although this document sometimes refers to a “transformation” between a “character” within a “string” and the 16-bit unsigned integer that is the UTF-16 encoding of that character, there is actually no transformation because a “character” within a “string” is actually represented using that 16-bit unsigned value.

NOTE 2
ECMAScript differs from the Java programming language in the behaviour 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 an ECMAScript program is first converted into a sequence of input elements, which are either tokens, line terminators, comments, or white space. The source text is scanned from left to right, repeatedly taking the longest possible sequence of characters as the next input element.

There are two goal symbols for the lexical grammar. TheInputElementDiv symbol is used in those syntactic grammar contexts where a division (/) or division-assignment (/=) operator is permitted. TheInputElementRegExp symbol is used in other syntactic grammar contexts.

Note that contexts exist in the syntactic grammar where both a division and a RegularExpressionLiteral are permitted by the syntactic grammar; however, since the lexical grammar uses theInputElementDiv goal symbol in such cases, the opening slash is not recognised as starting a regular expression literal in such a context. As a workaround, one may enclose the regular expression literal in parentheses.

7.1 Unicode Format-Control Characters

The Unicode format-control characters (i.e., the characters in category “Cf” in the Unicode Character Database such as LEFT-TO-RIGHT MARK or RIGHT-TO-LEFT MARK) are control codes used to control the formatting of a range of text in the absence of higher-level protocols for this (such as mark-up languages). It is useful to allow these in source text to facilitate editing and display.

The format control characters may be used in identifiers, within comments, and within string literals and regular expression literals.

7.2 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:

<table>
<thead>
<tr>
<th>Code Point Value</th>
<th>Name</th>
<th>Formal Name</th>
</tr>
</thead>
</table>

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ECMAScript implementations must recognize all of the white space characters defined in Unicode 3.0. Later editions of the Unicode Standard may define other white space characters. ECMAScript implementations may recognize white space characters from later editions of the Unicode Standard.

**Syntax**

WhiteSpace ::= 
  <TAB> |
  <VT> |
  <FF> |
  <SP> |
  <NEL> |
  <NBSP> |
  <ZWSP> |
  <BOM> |
  <USP> |

7.3 Line Terminators

Like white space characters, line terminator characters are used to improve source text readability and to separate tokens (indivisible lexical units) from each other. However, unlike white space characters, line terminators have some influence over the behaviour 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, except that line terminators that are preceded by an escape sequence may occur within a string literal token. Line terminators also affect the process of automatic semicolon insertion (7.9).

Line terminators are included in the set of white space characters that are matched by the \s class in regular expressions.

The following characters are considered to be line terminators:

<table>
<thead>
<tr>
<th>Code Point Value</th>
<th>Name</th>
<th>Formal Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>\u000A</td>
<td>Line Feed</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>\u000D</td>
<td>Carriage Return</td>
<td>&lt;CR&gt;</td>
</tr>
<tr>
<td>\u2028</td>
<td>Line separator</td>
<td>&lt;LS&gt;</td>
</tr>
<tr>
<td>\u2029</td>
<td>Paragraph separator</td>
<td>&lt;PS&gt;</td>
</tr>
</tbody>
</table>

Only the characters in the above table are treated as line terminators. Other new line or line breaking characters are treated as white space but not as line terminators. The character sequence <CR><LF> is treated as a single line terminator.

**Syntax**
7.4 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 a 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 recognised 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 (7.9).

Comments behave like white space and are discarded except that, if a MultiLineComment contains a line terminator character, then the entire comment is considered to be a LineTerminator for purposes of parsing by the syntactic grammar.

Syntax

Comment ::
  MultiLineComment
  SingleLineComment

MultiLineComment ::
  /* MultiLineCommentChars_opt */

MultiLineCommentChars ::
  MultiLineNotAsteriskChar MultiLineCommentChars_opt
  * PostAsteriskCommentChars_opt

PostAsteriskCommentChars ::
  MultiLineNotForwardSlashOrAsteriskChar MultiLineCommentChars_opt
  * PostAsteriskCommentChars_opt

MultiLineNotAsteriskChar ::
  SourceCharacter but not asterisk *

MultiLineNotForwardSlashOrAsteriskChar ::
  SourceCharacter but not forward-slash / or asterisk *

SingleLineComment ::
  // SingleLineCommentChars_opt

SingleLineCommentChars ::
  SingleLineCommentChar SingleLineCommentChars_opt

SingleLineCommentChar ::
  SourceCharacter but not LineTerminator

7.5 Tokens

Syntax
Token ::
   ReservedWord
   Identifier
   IdentifierName
   Punctuator
   NumericLiteral
   StringLiteral

7.5.1 Reserved Words
Description
Reserved words cannot be used as identifiers.

Syntax
ReservedWord ::
   Keyword
   FutureReservedWord
   NullLiteral
   BooleanLiteral

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

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

7.5.3 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
   abstract enum int short
   boolean export interface static
   byte extends long super
   char final native synchronized
   class float package throws
   const goto private transient
   [implements] protected volatile
   double import public

Note
TBD: Need to have a note alluding to the future use of ‘const’, ‘let’, and ‘yield’.

7.6 Identifiers
Description
Identifiers are interpreted according to the grammar given in Section 5.16 of the Unicode standard, with some small modifications. This grammar is based on both normative and informative character categories specified by the Unicode Standard. The characters in the specified categories in version 3.0 of the Unicode standard must be treated as in those categories by all conforming ECMAScript implementations; however, conforming ECMAScript implementations may allow additional legal identifier characters based on the category assignment from later versions of Unicode.
This standard specifies specific character additions: The dollar sign ($) and the underscore (_) are permitted anywhere in an identifier.

Unicode escape sequences are also permitted in identifiers, where they contribute a single character to the identifier, as computed by the CV of the UnicodeEscapeSequence (see 7.8.4). The \ preceding the UnicodeEscapeSequence does not contribute a character to the identifier. A UnicodeEscapeSequence cannot be used to put a character into an identifier that would otherwise be illegal. In other words, if a \ UnicodeEscapeSequence sequence were replaced by its UnicodeEscapeSequence's CV, the result must still be a valid Identifier that has the exact same sequence of characters as the original Identifier.

Two identifiers that are canonically equivalent according to the Unicode standard are not equal unless they are represented by the exact same sequence of code points (in other words, conforming ECMAScript implementations are only required to do bitwise comparison on identifiers). The intent is that the incoming source text has been converted to normalised form C before it reaches the compiler.

ECMAScript implementations may recognize identifier characters defined in later editions of the Unicode Standard. If portability is a concern, programmers should only employ identifier characters defined in Unicode 3.0.

Syntax

Identifier ::= IdentifierName but not ReservedWord

IdentifierName ::
  IdentifierStart IdentifierName IdentifierPart

IdentifierStart ::
  UnicodeLetter
  $ UnicodeEscapeSequence

IdentifierPart ::
  IdentifierStart
  UnicodeCombiningMark
  UnicodeDigit
  UnicodeConnectorPunctuation
  \ UnicodeEscapeSequence

UnicodeLetter
  any character in the Unicode categories “Uppercase letter (Lu)”, “Lowercase letter (Ll)”, “Titlecase letter (Lt)”, “Modifier letter (Lm)”, “Other letter (Lo)”, or “Letter number (Nl)”.

UnicodeCombiningMark
  any character in the Unicode categories “Non-spacing mark (Mn)” or “Combining spacing mark (Mc)”

UnicodeDigit
  any character in the Unicode category “Decimal number (Nd)”

UnicodeConnectorPunctuation
  any character in the Unicode category “Connector punctuation (Pc)”

UnicodeEscapeSequence
  see 7.8.4.

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
7.7 Punctuators

Syntax

Punctuator ::= one of
{( ) [ ] - ; , < > <= >= !== == !== + - * % ++ -- << >>> & | ^

DivPunctuator ::= one of
/
/=)

7.8 Literals

Syntax

Literal ::= NullLiteral
BooleanLiteral
NumericLiteral
StringLiteral

7.8.1 Null Literals

Syntax
NullLiteral ::= null

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

7.8.2 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.

7.8.3 Numeric Literals

Syntax
NumericLiteral ::= DecimalLiteral m
HexIntegerLiteral

DecimalLiteral ::= DecimalIntegerLiteral . DecimalDigits opt ExponentPart opt
. DecimalDigits ExponentPart opt
DecimalIntegerLiteral ExponentPart opt

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DecimalIntegerLiteral ::
    0
    NonZeroDigit DecimalDigits

DecimalDigits ::
    DecimalDigit
    DecimalDigits DecimalDigit

DecimalDigit :: one of
    0 1 2 3 4 5 6 7 8 9

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

The source character immediately following a NumericLiteral must not be an IdentifierStart or DecimalDigit.

NOTE
For example:

3in

is an error and not the two input elements 3 and in.

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 as described below.

The MV of DecimalIntegerLiteral :: DecimalLiteral is the MV of DecimalLiteral.
The MV of NumericLiteral :: HexIntegerLiteral is the MV of HexIntegerLiteral.
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 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 is the MV of DecimalIntegerLiteral.
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 \( :: \text{NonZeroDigit} \) 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 \( :: \text{DecimalDigit} \) is the MV of DecimalDigit.
The MV of DecimalDigits \( :: \text{DecimalDigits} \) DecimalDigit is (the MV of DecimalDigits times \( 10^k \)) plus the MV of DecimalDigit.
The MV of ExponentPart \( :: \text{ExponentIndicator} \) SignedInteger is the MV of SignedInteger.
The MV of SignedInteger \( :: \text{DecimalDigits} \) is the MV of DecimalDigits.
The MV of SignedInteger \( :: + \text{DecimalDigits} \) 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 NonZeroDigit \( :: 1 \) or of HexDigit \( :: 1 \) is 1.
The MV of DecimalDigit \( :: 2 \) or of NonZeroDigit \( :: 2 \) or of HexDigit \( :: 2 \) is 2.
The MV of DecimalDigit \( :: 3 \) or of NonZeroDigit \( :: 3 \) or of HexDigit \( :: 3 \) is 3.
The MV of DecimalDigit \( :: 4 \) or of NonZeroDigit \( :: 4 \) or of HexDigit \( :: 4 \) is 4.
The MV of DecimalDigit \( :: 5 \) or of NonZeroDigit \( :: 5 \) or of HexDigit \( :: 5 \) is 5.
The MV of DecimalDigit \( :: 6 \) or of NonZeroDigit \( :: 6 \) or of HexDigit \( :: 6 \) is 6.
The MV of DecimalDigit \( :: 7 \) or of NonZeroDigit \( :: 7 \) or of HexDigit \( :: 7 \) 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 \( :: \text{a} \) or of HexDigit \( :: \text{a} \) is 10.
The MV of HexDigit \( :: \text{b} \) or of HexDigit \( :: \text{b} \) is 11.
The MV of HexDigit \( :: \text{c} \) or of HexDigit \( :: \text{c} \) is 12.
The MV of HexDigit \( :: \text{d} \) or of HexDigit \( :: \text{d} \) is 13.
The MV of HexDigit \( :: \text{e} \) or of HexDigit \( :: \text{e} \) is 14.
The MV of HexDigit \( :: \text{f} \) or of HexDigit \( :: \text{f} \) is 15.
The MV of HexIntegerLiteral \( :: 0\text{X} \) HexDigit is the MV of HexDigit.
The MV of HexIntegerLiteral \( :: 0\text{X} \) HexDigit is the MV of HexDigit.
The MV of HexIntegerLiteral \( :: 0\text{X} \) HexIntegerLiteral HexDigit is (the MV of HexIntegerLiteral times 16) plus the MV of HexDigit.

Once the exact MV for a numeric literal has been determined, it is then rounded to a value of the Decimal type if the suffix \( \text{m} \) is present, otherwise to the Number type. If the MV is 0, then the rounded value is +0; otherwise, the rounded value must be the number value for the MV (in the sense defined in 8.5), unless the literal is a DecimalLiteral and the literal has more than 20 significant digits, in which case the number value may be either the number value for the MV of a literal produced by replacing each significant digit after the 20th with a 0 digit or the number value for the MV of a literal produced by replacing each significant digit after the 20th with a 0 digit and then incrementing the literal at the 20th significant digit position. A digit is significant if it is not part of an ExponentPart and it is not 0; or there is a nonzero digit to its left and there is a nonzero digit, not in the ExponentPart, to its right.

### 7.8.4 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. All Unicode characters may appear literally in a string literal except for the closing quote character, backslash, carriage return, and line feed. Any character may appear in the form of an escape sequence.

**Syntax**

07 November 2008
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 7.8.3. The SV of `StringLiteral :: " "` is the empty character sequence.
The SV of StringLiteral :: '')' is the empty character sequence.
The SV of StringLiteral :: type 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 SV of LineContinuation :: \LineTerminator is the empty character sequence.
The CV of DoubleStringCharacter :: SourceCharacter but not double-quote = or slash \ 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 slash \ 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 :: 0 (lookahead in a StringLiteral is a <NUL> character (Unicode value 0000)).
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 character whose code point value is determined by the SingleEscapeCharacter according to the following table:

<table>
<thead>
<tr>
<th>Escape Sequence</th>
<th>Code Point Value</th>
<th>Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>\b</td>
<td>\u0008</td>
<td>backspace</td>
<td>&lt;BS&gt;</td>
</tr>
<tr>
<td>\t</td>
<td>\u0009</td>
<td>horizontal tab</td>
<td>&lt;HT&gt;</td>
</tr>
<tr>
<td>\n</td>
<td>\u000A</td>
<td>line feed (new line)</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>\v</td>
<td>\u000B</td>
<td>vertical tab</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>\f</td>
<td>\u000C</td>
<td>form feed</td>
<td>&lt;FF&gt;</td>
</tr>
<tr>
<td>\r</td>
<td>\u000D</td>
<td>carriage return</td>
<td>&lt;CR&gt;</td>
</tr>
<tr>
<td>&quot;</td>
<td>\u0022</td>
<td>double quote</td>
<td>&quot;</td>
</tr>
<tr>
<td>'</td>
<td>\u0027</td>
<td>single quote</td>
<td>'</td>
</tr>
<tr>
<td>\</td>
<td>\u005C</td>
<td>backslash</td>
<td>\</td>
</tr>
</tbody>
</table>

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 :: x HexDigit HexDigit HexDigit is the character whose code point value is (16 times the MV of the first HexDigit) plus the MV of the second HexDigit.
The CV of UnicodeEscapeSequence :: u HexDigit HexDigit HexDigit HexDigit HexDigit is the character whose code point value is (4096 (that is, 16^4) times the MV of the first HexDigit) plus (256 (that is, 16^2) times the MV of the second HexDigit) plus (16 times the MV of the third HexDigit) plus the MV of the fourth HexDigit.

NOTE
A 'LineTerminator' character cannot appear in a string literal, except when preceded by a backslash \ as a 'LineContinuation' to produce the empty character sequence. 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.
7.8.5 Regular Expression Literals

A regular expression literal is an input element that is converted to a RegExp object (section 15.10) each time the literal is evaluated. Two regular expression literals in a program evaluate to regular expression objects that never compare as === to each other even if the two literals’ contents are identical. A RegExp object may also be created at runtime by new RegExp (section 15.10.4) or calling the RegExp constructor as a function (section 15.10.3).

The productions below describe the syntax for a regular expression literal and are used by the input element scanner to find the end of the regular expression literal. The strings of characters comprising the RegularExpressionBody and the RegularExpressionFlags are passed uninterpreted to the regular expression constructor, which interprets them according to its own, more stringent grammar. An implementation may extend the regular expression constructor’s grammar, but it should not extend the RegularExpressionBody and RegularExpressionFlags productions or the productions used by these productions.

Syntax

```
RegularExpressionLiteral::
  / RegularExpressionBody / RegularExpressionFlags

RegularExpressionBody ::
  RegularExpressionFirstChar RegularExpressionChars

RegularExpressionChars ::
  [empty]
  RegularExpressionFirstChar RegularExpressionChars

RegularExpressionFirstChar ::
  NonTerminator but not \ or /
  BackslashSequence

RegularExpressionChar ::
  NonTerminator but not \ /
  BackslashSequence

BackslashSequence ::
  \ NonTerminator

NonTerminator ::
  SourceCharacter but not LineTerminator

RegularExpressionFlags ::
  [empty]
  RegularExpressionFlags IdentifierPart
```

NOTE

Regular expression literals may not be empty; instead of representing an empty regular expression literal, the characters /// start a single-line comment. To specify an empty regular expression, use /(/?/)/.

Semantics

A regular expression literal evaluates to a value of the RegExp type. This value is determined in two steps: first, the characters comprising the regular expression’s RegularExpressionBody and RegularExpressionFlags production expansions are collected uninterpreted into two strings Pattern and Flags, respectively. Then each time the literal is evaluated, a new object is created as if by the expression new RegExp(Pattern, Flags) where RegExp is the standard built-in constructor with that name. The newly constructed object becomes the value of the RegularExpressionLiteral. If the call to new RegExp would generate an error, the error must be reported while scanning the program.

07 November 2008
Automatic Semicolon Insertion

Certain ECMAScript statements (empty statement, variable statement, expression statement, do-while statement, continue statement, break statement, return statement, and throw statement) must be terminated with semicolons. Such semicolons may always appear explicitly in the source text. For convenience, however, such semicolons may be omitted from the source text in certain situations. These situations are described by saying that semicolons are automatically inserted into the source code token stream in those situations.

7.9.1 Rules of Automatic Semicolon Insertion

- When 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, 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 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.

- When 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 a semicolon is automatically inserted before the restricted token.

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 or if that semicolon would become one of the two semicolons in the header of a for statement (section 12.6.3).

NOTE
These are the only restricted productions in the grammar:

- PostfixExpression:
  - LeftHandSideExpression [no LineTerminator here] ++
  - LeftHandSideExpression [no LineTerminator here] --

- ContinueStatement:
  - continue [no LineTerminator here] Identifieropt ;

- BreakStatement:
  - break [no LineTerminator here] Identifieropt ;

- ReturnStatement:
  - return [no LineTerminator here] Expressionopt ;

- ThrowStatement:
  - throw [no LineTerminator here] Expressionopt ;

The practical effect of these restricted productions is as follows:

- When a ++ or -- token 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.

- When a continue, break, return, or throw token is encountered and a LineTerminator is encountered before the next token, a semicolon is automatically inserted after the continue, break, return, or throw token.

The resulting practical advice to ECMAScript programmers is:

- A postfix ++ or -- operator should appear on the same line as its operand.
• An Expression in a `return` or `throw` statement should start on the same line as the `return` or `throw` token.
• A label in a `break` or `continue` statement should be on the same line as the `break` or `continue` token.

7.9.2 Examples of Automatic Semicolon Insertion

The source

```javascript
{ 1 2 } 3
```

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

```javascript
{ 1 2 } 3
```

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

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

which is a valid ECMAScript sentence.

The source

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

is not a valid ECMAScript sentence and is not altered by automatic semicolon insertion because the semicolon is needed for the header of a `for` statement. Automatic semicolon insertion never inserts one of the two semicolons in the header of a `for` statement.

The source

```javascript
return a + b
```

is transformed by automatic semicolon insertion into the following:

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

**NOTE**
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

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

is transformed by automatic semicolon insertion into the following:

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

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

The source

```javascript
if (a > b)
else c = d
```
is not a valid ECMAScript sentence and is not altered by automatic semicolon insertion before the \texttt{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.

The source
\begin{verbatim}
a = b + c
(d + e).print()
\end{verbatim}

is not transformed by automatic semicolon insertion, because the parenthesised expression that begins the second line can be interpreted as an argument list for a function call:
\begin{verbatim}
a = b + c(d + e).print()
\end{verbatim}

In the circumstance that an assignment statement must begin with a left parenthesis, it is a good idea for the programmer to provide an explicit semicolon at the end of the preceding statement rather than to rely on automatic semicolon insertion.

8 Types

A value is an entity that takes on one of eleven types. There are eleven types (Undefined, Null, Boolean, String, Number, Object, Reference, List, Completion, Property Descriptor, and Property Identifier). Values of type Reference, List, and Completion are used only as intermediate results of expression evaluation and cannot be stored as properties of objects.

8.1 The Undefined Type

The Undefined type has exactly one value, called \texttt{undefined}. Any variable that has not been assigned a value has the value \texttt{undefined}.

8.2 The Null Type

The Null type has exactly one value, called \texttt{null}.

8.3 The Boolean Type

The Boolean type represents a logical entity having two values, called \texttt{true} and \texttt{false}.

8.4 The String Type

The String type is the set of all finite ordered sequences of zero or more 16-bit unsigned integer values (“elements”). The String type is generally used to represent textual data in a running ECMAScript program, in which each element in the string is treated as a code point value (see section 6). Each element is regarded as occupying a position within the sequence. These positions are indexed with nonnegative integers. The first element (if any) is at position 0, the next element (if any) at position 1, and so on. The length of a string is the number of elements (i.e., 16-bit values) within it. The empty string has length zero and therefore contains no elements.

When a string contains actual textual data, each element is considered to be a single UTF-16 unit. Whether or not this is the actual storage format of a String, the characters within a String are numbered as though they were represented using UTF-16. All operations on Strings (except as otherwise stated) treat them as sequences of undifferentiated 16-bit unsigned integers; they do not ensure the resulting string is in normalised form, nor do they ensure language-sensitive results.

NOTE

The rationale behind these decisions was to keep the implementation of Strings as simple and high-performing as possible. The intent is that textual data coming into the execution environment from outside (e.g., user input, text read from a file or received over the network, etc.) be converted to Unicode Normalised Form C before the running program sees it. Usually this would occur at the same time incoming text is converted from its original character encoding to Unicode (and would impose no additional overhead). Since it is recommended that ECMAScript source code be in Normalised Form C, string literals are guaranteed to be normalised (if source text is guaranteed to be normalised), as long as they do not contain any Unicode escape sequences.
8.5 The Number and the Decimal Types

The Number type has exactly $18437736874454810627$ (that is, $2^{34} - 2^{33} - 1$) values, representing the double-precision 64-bit format IEEE 754 values as specified in the IEEE Standard for Floating-Point Arithmetic, except that the $9007199254740990$ (that is, $2^{33} - 2$) 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 behaviour is implementation-dependent; to ECMAScript code, all NaN values are indistinguishable from each other.

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 +∞ and −∞, 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 Decimal type has exactly $10^{53} \times 12288 + 3$ values, representing the quadrupal-precision 128-bit format IEEE 754-2008 format values as specified in the IEEE Standard for Floating-Point Arithmetic, except that the $10^{53}$ distinct NaN, positive infinity and negative infinity values are are represented in ECMAScript as a single NaN, +Infinity, and −Infinity values.

The other $18437736874454810624$ (that is, $2^{34} - 2^{33} - 2$) for Number and $10^{53} \times 12288$ for Decimal 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 each type has 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, $2^{34} - 2^{33} - 2$) for Number and $10^{53} \times 12288 + 2$ for Decimal finite nonzero values are of two kinds:

$18428729675200069632$ (that is, $2^{26} - 2^{26} - 2$) for Number and $10^{53} + 12288$ for Decimal are normalised, having the form $s \times m \times \text{base}^e$. For Number $s$ is +1 or −1, $m$ is a positive integer less than $2^{53}$ but not less than $2^{52}$, base is 2, and $e$ is an integer ranging from −1074 to 971, inclusive.

For Decimal, $s$ is +1 or −1, $m$ is a positive integer less than $10^{54}$ but with a least significant digit of anything but zero, base is 10, and $e$ is an integer ranging from −6143 to 6144, inclusive.

The remaining $9007199254740990$ (that is, $2^{33} - 2^{33} - 2$) for Number and $9 \times 10^{53} + 12288$ for Decimal values are denormalised, having the form $s \times m \times \text{base}^e$. For Number $s$ is +1 or −1, $m$ is a positive integer less than $2^{52}$, base is 10, and $e$ is −1074.

For Decimal, $s$ is +1 or −1, $m$ is a positive integer less than $10^{54}$ but with a least significant digit of zero, base is 10, and $e$ is an integer ranging from −6143 to 6144, inclusive.

Note that all the positive and negative integers whose magnitude is no greater than $2^{53}$ are representable in the Number type (indeed, the integer 0 has two representations, +0 and −0), and that all of the positive integers no greater than $10^{10}$ are representable in the Decimal type.

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, 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 underlying type, namely $2^{1024}$ (which is +1...
\(2^{31} \times 2^{971}\) and \(-2^{31}\) (which is \(-1 \times 2^{31} \times 2^{971}\) for Number and \(10^{8179}\) and \(-10^{8179}\) for Decimal). 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 are considered to have even significands. Finally, if an extra value was chosen, replace it with \(+\infty\) if positive and \(-\infty\) if negative; 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 behaviour 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 a collection of properties. Each property is either a named data property, a named accessor property, or an internal property.

- A named data property associates a name with a value and a set of boolean attributes.
- A named accessor property associates a name with a getter method, a setter method, and a set of boolean attributes.
- An internal property has no name and is not directly accessible via the property accessor operators. Internal properties exist purely for specification purposes. How and when some of these properties are used is specified by the language specification below.

8.6.1 Property Attributes

Attributes are used in this specification to define and explain the state of named properties. A named data property associates a name with the following attributes:

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Value]]</td>
<td>any</td>
<td>The value retrieved by reading the property.</td>
</tr>
<tr>
<td>[[Writable]]</td>
<td>boolean</td>
<td>If true, attempts by ECMAScript code to assign the property’s value will succeed.</td>
</tr>
<tr>
<td>[[Enumerable]]</td>
<td>boolean</td>
<td>If true, the property will be enumerated by a for-in enumeration (section 12.6.4). Otherwise, the property is said to be non-enumerable.</td>
</tr>
<tr>
<td>[[Configurable]]</td>
<td>boolean</td>
<td>If true, attempts to delete the property, change the property to being an accessor property, or change its attributes will succeed. See the description of the delete operator in section 11.4.1 and the reflective Object methods.</td>
</tr>
</tbody>
</table>

A named accessor property associates a name with the following attributes:

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Getter]]</td>
<td>function or undefined</td>
<td>A method that to be called each time the property is read, to retrieve the current value of the property.</td>
</tr>
<tr>
<td>[[Setter]]</td>
<td>function or undefined</td>
<td>A method to be called each time the property is assigned to, in order to define the current value of the property.</td>
</tr>
</tbody>
</table>
If true, the property is to be enumerated by a for-in enumeration (section 12.6.4). Otherwise, the property is said to be non-enumerable.

If true, attempts to delete the property, change the property to a data property, or change its attributes will succeed. See the description of the delete operator in section 11.4.1, and the reflective Object methods.

If the value of an attribute is not explicitly specified for a named property, the default value as defined in the following table is used:

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[Value]]</td>
<td>undefined</td>
</tr>
<tr>
<td>[[Getter]]</td>
<td>undefined</td>
</tr>
<tr>
<td>[[Setter]]</td>
<td>undefined</td>
</tr>
<tr>
<td>[[Writable]]</td>
<td>false</td>
</tr>
<tr>
<td>[[Enumerable]]</td>
<td>false</td>
</tr>
<tr>
<td>[[Configurable]]</td>
<td>false</td>
</tr>
</tbody>
</table>

Property descriptors, defined in section 8.10, are internal types used within this specification to describe manipulations of property attributes.

### 8.6.2 Internal Properties and Methods

Internal properties and methods are not part of the language. They are defined by this specification purely for expository purposes. An implementation of ECMAScript must behave as if it produced and operated upon internal properties in the manner described here. For the purposes of this document, the names of internal properties are 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 `TypeError` exception is thrown.

There are two types of access for normal (non-internal) properties: `get` and `put`, corresponding to retrieval and assignment, respectively.

All 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. Named data properties of the `[[Prototype]]` object are inherited (are visible as properties of the child object) for the purposes of `get` access, but not for `put` access. Named accessor properties are inherited for both `get` access and `put` access.

The following table summarises the internal properties used by this specification that are applicable to all ECMAScript objects. The description indicates their behaviour for native ECMAScript objects, unless stated otherwise in this document for particular types of ECMAScript objects. In particular, Array objects have a slightly different definition of the `[[ThrowablePut]]` method (see 15.4.5.1) and String objects have a different definition of the `[[GetOwnProperty]]` method. Host objects may support these internal properties with any implementation-dependent behaviour, or it may be that a host object supports only some internal properties and not others.
Every object (including host objects) must implement the `[[Prototype]]`, `[[Class]]`, and `[[Extensible]]` internal data properties and the `[[Get]]`, `[[GetMethod]]`, `[[GetProperty]]`, `[[GetOwnProperty]]`, `[[Put]]`, `[[CanPut]]`, `[[HasProperty]]`, `[[Delete]]`, and `[[DefaultValue]]` internal methods. (Note, however, that the `[[DefaultValue]]` method may, for some objects, simply throw a `TypeError` exception.)

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). Whether or not a native object can have a host object as its `[[Prototype]]` depends on the implementation.

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. The value of a `[[Class]]` property is used internally to distinguish different kinds of built-in objects. Note that this specification does not provide any means for a program to access that value except through `Object.prototype.toString` (see 15.2.4.2).

### Table: Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>[[Prototype]]</code></td>
<td>`Object</td>
<td>null`</td>
</tr>
<tr>
<td><code>[[Class]]</code></td>
<td>string</td>
<td>A string value indicating the kind of this object.</td>
</tr>
<tr>
<td><code>[[ProtoProperty]]</code></td>
<td><code>primitive</code></td>
<td>Internal state information associated with this object.</td>
</tr>
<tr>
<td><code>[[Extensible]]</code></td>
<td>boolean</td>
<td>If true, own properties may be added to the object.</td>
</tr>
<tr>
<td><code>[[Get]]</code></td>
<td>function(PropertyName)</td>
<td>Returns the value of the named property.</td>
</tr>
<tr>
<td><code>[[GetOwnProperty]]</code></td>
<td>function(PropertyName)</td>
<td>Returns the Property Descriptor of the named own property of this object, or <code>undefined</code> if absent.</td>
</tr>
<tr>
<td><code>[[GetProperty]]</code></td>
<td>function(PropertyName)</td>
<td>Returns the Property Descriptor of the named property of this object, or <code>undefined</code> if absent.</td>
</tr>
<tr>
<td><code>[[CanPut]]</code></td>
<td>function(PropertyName, any)</td>
<td>Returns the specified named property to specified value.</td>
</tr>
<tr>
<td><code>[[HasProperty]]</code></td>
<td>boolean</td>
<td>Returns a boolean value indicating whether a <code>[[Put]]</code> operation with <code>PropertyName</code> can be performed.</td>
</tr>
<tr>
<td><code>[[Delete]]</code></td>
<td>function(PropertyName, boolean)</td>
<td>Removes the specified named own property from the object. The flag controls failure handling.</td>
</tr>
<tr>
<td><code>[[DefaultValue]]</code></td>
<td>function(Hint) = any</td>
<td>Returns a default value for the object, which should be a primitive value (not an object or reference).</td>
</tr>
<tr>
<td><code>[[DefineOwnProperty]]</code></td>
<td>function(PropertyName, PropertyDescriptor, boolean)</td>
<td>Creates or alters the named own property to have the state described by a Property Descriptor. The flag controls failure handling.</td>
</tr>
<tr>
<td><code>[[ThrowABPut]]</code></td>
<td>function(PropertyName, any, boolean)</td>
<td>Sets the specified named property to <code>Value</code>. The flag controls failure handling.</td>
</tr>
<tr>
<td><code>[[Construct]]</code></td>
<td>function(a list of argument values provided by the caller) → <code>Object</code></td>
<td>Constructs an object, invoked via the <code>new</code> operator. Objects that implement this internal method are called <code>constructor</code>.</td>
</tr>
<tr>
<td><code>[[Call]]</code></td>
<td>function(a list of argument values provided by the caller) → any</td>
<td>Executes code associated with the object. Invoked via a function call expression. Objects that implement this internal method are called <code>functions</code>.</td>
</tr>
<tr>
<td><code>[[HasInstance]]</code></td>
<td>function(any) → boolean</td>
<td>Returns a boolean value indicating whether <code>Value</code> delegates behaviour to this object. Of the native ECMAScript objects, only Function objects implement <code>[[HasInstance]]</code>.</td>
</tr>
<tr>
<td><code>[[Scope]]</code></td>
<td><code>lexical environment</code> that defines the environment in which a Function object is executed.</td>
<td></td>
</tr>
<tr>
<td><code>[[Match]]</code></td>
<td>function(string, index) = MatchResult</td>
<td>Tests for a regular expression match and returns a MatchResult value (see section 15.10.2.1).</td>
</tr>
</tbody>
</table>

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For native objects the [[Get]], [[Put]], [[CanPut]], [[HasProperty]], [[Delete]] and [[DefaultValue]] methods behave as described in described in 8.6.2.1, 8.6.2.2, 8.6.2.3, 8.6.2.4, 8.6.2.5 and 8.6.2.6, respectively, except that Array objects have a slightly different implementation of the [[Put]] method (see 15.4.5.1). Host objects may implement these methods in any manner unless specified otherwise; for example, one possibility is that [[Get]] and [[Put]] for a particular host object indeed fetch and store property values but [[HasProperty]] always generates false.

In the following algorithm descriptions, assume $O$ is a native ECMAScript object, $P$ is a string, Desc is an internal property description record, and $Throw$ is a boolean flag.

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

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

1. Call the [[GetProperty]] method of $O$ with property name $P$.
2. If Result(1) is undefined, return undefined.
3. If IsDataDescriptor(Result(1)) is true, return Result(1).[[Value]].
4. Otherwise, IsAccessorDescriptor(Result(1)) must be true so, get Result(1).[[Getter]].
5. If Result(4) is undefined, return undefined.
6. Call the [[Call]] method of Result(4) providing $O$ as the this value and providing no arguments.
7. Return Result(6).

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

[[Put]] is primarily used in the specification of built-in methods. Algorithms that require explicit control over the handling of invalid property store should call [[ThrowablePut]] directly.

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

2. Return.

Note, however, that if $O$ is an Array object, it has a more elaborate [[Put]] method (15.4.5.1).

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

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

1. Call the [[GetOwnProperty]] method of $O$ with argument $P$.
2. If Result(1) is not undefined, then
   a. If IsAccessorDescriptor(Result(1)) is true, then
      i. If Result(1).[[setter]] is undefined, then return false.
      ii. Else return true.
   b. Otherwise, Result(1) must be a DataDescriptor so return the value of Result(1).[[Writable]].
3. Get the internal [[Prototype]] property of $O$.
4. If Result(3) is null, then return the value of the [[Extensible]] property of $O$.
5. Call the [[GetProperty]] method of Result(3) with property name $P$.
6. If Result(5) is undefined, return the value of the [[Extensible]] property of $O$.
7. If IsAccessorDescriptor(Result(5)) is true, then
   a. If Result(5).[[setter]] is undefined, then return false.
   b. Else return true.
8. Else, Result(5) must be a DataDescriptor
   a. If the [[Extensible]] property of $O$ is false, return false.
   b. Else return the value of Result(5).[[Writable]].

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

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

1. Call the [[GetProperty]] method of $O$ with property name $P$.
2. If Result(1) is undefined, then return false.
3. Else return true.
8.6.2.5 [[Delete]] (P, Throw)
When the [[Delete]] method of O is called with property name P and the boolean flag Throw, the following steps are taken:

1. Call the [[GetOwnProperty]] method of O with property name P.
2. If Result(1) is undefined, then return true.
3. If Result(1).[[Configurable]] is true, then
   a. Remove the own property with name P from O.
   b. Return true.
4. Else if Throw, then throw a TypeError exception.
5. Return false.

8.6.2.6 [[DefaultValue]] (hint)
When the [[DefaultValue]] method of O is called with hint String, the following steps are taken:

1. Call the [[Get]] method of object O with argument "toString".
2. If Result(1) is not an object, go to step 5.
3. Call the [[Call]] method of Result(1), with O as the this value and an empty argument list.
4. If Result(3) is a primitive value, return Result(3).
5. Call the [[Get]] method of object O with argument "valueOf".
6. If Result(5) is not an object, go to step 9.
7. Call the [[Call]] method of Result(5), with O as the this value and an empty argument list.
8. If Result(7) is a primitive value, return Result(7).
9. Throw a TypeError exception.

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

1. Call the [[Get]] method of object O with argument "valueOf".
2. If Result(1) is not an object, go to step 5.
3. Call the [[Call]] method of Result(1), with O as the this value and an empty argument list.
4. If Result(3) is a primitive value, return Result(3).
5. Call the [[Get]] method of object O with argument "toString".
6. If Result(5) is not an object, go to step 9.
7. Call the [[Call]] method of Result(5), with O as the this value and an empty argument list.
8. If Result(7) is a primitive value, return Result(7).
9. Throw a TypeError exception.

When the [[DefaultValue]] method of O is called with no hint, then it behaves as if the hint were String, in which case it behaves as if the hint were Number. If a host object implements its own [[DefaultValue]] method, it must ensure that its [[DefaultValue]] method can return only primitive values.

8.6.2.7 [[GetProperty]] (P)
When the [[GetProperty]] method of O is called with property name P, the following steps are taken:

1. Call the [[GetOwnProperty]] method of O with property name P.
2. If Result(1) is not undefined, return Result(1).
3. If the [[Prototype]] of O is null, return undefined.
4. Call the [[HasProperty]] method of [[Prototype]] with property name P.
5. Return Result(4).

8.6.2.8 [[GetOwnProperty]] (P)
When the [[GetOwnProperty]] method of O is called with property name P, the following steps are taken:

1. If O doesn’t have an own property with name P, return undefined.
2. Let D be a newly created Property Descriptor (Section 8.10) with no fields.
3. Let X be O’s own property named P.
4. If X is a data property, then
   a. Set D.([Value]) to the value of X’s [[Value]] attribute.
   b. Set D.([Writable]) to the value of X’s [[Writable]] attribute.
5. Else X is an accessor property, so
   a. Set D.([Getter]) to the value of X’s [[Getter]] attribute.
   b. Set D.([Setter]) to the value of X’s [[Setter]] attribute.
6. Set D.([Enumerable]) to the value of X’s [[Enumerable]] attribute.
7. Set D.([Configurable]) to the value of X’s [[Configurable]] attribute.
8. Return D.

Note, however, that if O is a String object it has a more elaborate [[GetOwnProperty]] method (15.5.5.2).

8.6.2.9 [[DefineOwnProperty]] (P, Desc, Throw)
In the following algorithm, the term “Reject” means “If Throw is true, then throw a TypeError exception, otherwise return.”

When the [[DefineOwnProperty]] method of O is called with property name P, property descriptor Desc, and boolean flag Throw, the following steps are taken:

1. Call the [[GetOwnProperty]] method of O with property name P.
2. Get the [[Extensible]] internal property of O.
3. If Result(1) is undefined and Result(2) is false, then Reject.
4. If Result(1) is undefined and Result(2) is true, then
   a. If IsGenericDescriptor(Desc) or IsDataDescriptor(Desc) is true, then
      i. Create an own data property named P of object O whose [[Value]], [[Writable]], [[Enumerable]] and [[Configurable]] attribute values are described by Desc. If the value of an attribute field of Desc is absent, the attribute of the newly created property is set to its default value.
   b. Else, Desc must be an accessor Property Descriptor so,
      i. Create an own accessor property named P of object O whose [[Getter]], [[Setter]], [[Enumerable]] and [[Configurable]] attribute values are described by Desc. If the value of an attribute field of Desc is absent, the attribute of the newly created property is set to its default value.
5. Return, if the value of every field in Desc is absent.
6. Return, if every field in Desc also occurs in Result(1) and the value of every field in Desc is the same value as the corresponding field in Result(1).
7. If the [[Configurable]] field of Result(1) is false then
   a. Reject, if the [[Configurable]] field of Desc is true
   b. Reject, if the [[Enumerable]] field of Result(1) and Desc are the Boolean negation of each other.
8. If IsGenericDescriptor(Desc) is true, then no further validation is required.
9. Else, if IsDataDescriptor(Result(1)) and IsDataDescriptor(Desc) have different results, then
   a. Reject, if the [[Configurable]] field of Result(1) is false.
   b. If IsDataDescriptor(Result(1)) is true, then
      i. Convert the property named P of object O from a data property to an accessor property. Preserve the existing values of the converted property’s [[Configurable]] and [[Enumerable]] attributes and set the the rest of the property’s attributes to their default values.
   c. Else,
      i. Convert the property named P of object O from an accessor property to a data property. Preserve the existing values of the converted property’s [[Configurable]] and [[Enumerable]] attributes and set the the rest of the property’s attributes to their default values.
10. Else, if IsDataDescriptor(Result(1)) and IsDataDescriptor(Desc) are both true, then
    a. If the [[Configurable]] field of Result(1) is false, then
       i. Reject, if the [[Writable]] field of Result(1) is false and the [[Writable]] field of Desc is true.
       ii. If the [[Writable]] field of Result(1) is false, then

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1. Reject, if the [[Value]] field of Desc is present and SameValue(Desc.\[Value\], Result(1).\[Value\]) is false.
   b. else, the [[Configurable]] field of Result(1) is true, so any change is acceptable.
11. Else, IsAccessorDescriptor(Result(1)) and IsAccessorDescriptor(Desc) are both true so,
   a. If the [[Configurable]] field of Result(1) is false, then
      i. Reject, if the [[Setter]] field of Desc is present and SameValue(Desc.\[Setter\], Result(1).\[Setter\]) is false.
      ii. Reject, if the [[Getter]] field of Desc is present and SameValue(Desc.\[Getter\], Result(1).\[Getter\]) is false.
12. For each attribute field of Desc that is present, set the correspondingly named attribute of the
    property named \( P \) of object \( O \) to the value of the field.
13. Return.

8.6.2.10 [[ThrowablePut]] ( \( P \), \( V \), \( Throw \) )
When the [[ThrowablePut]] method of \( O \) is called with property \( P \), value \( V \), and boolean flag \( Throw \)
the following steps are taken:
1. Call the [[CanPut]] method of \( O \) with argument \( P \).
2. If Result(1) is false, then
   a. If \( Throw \) is true, then throw a TypeError exception.
   b. Else return.
3. Call the [[GetOwnProperty]] method of \( O \) with argument \( P \).
4. If IsDataDescriptor(Result(3)) is true, then
   a. Set the [[Value]] attribute of property \( P \) of \( O \) to \( V \).
   b. Return.
5. Call the [[GetProperty]] method of \( O \) with argument \( P \).
6. If IsAccessorDescriptor(Result(5)) is true, then
   a. Get Result(5).\[Setter\] which cannot be undefined.
   b. Call the [[Call]] method of Result(6a) providing \( O \) as the this value and providing \( V \) as the sole-argument.
   c. If Result(6b) is true, then
      i. Set Result(5).\[Setter\] with argument \( P \).
   d. Else, create a named data property named \( P \) on object \( O \) whose attributes are:
      a. [[Value]]: \( V \).
      b. [[Writable]]: true.
      c. [[Enumerable]]: true.
      d. [[Configurable]]: true.
8. Return.

Note, however, that if \( O \) is an Array object, it has a more elaborate [[ThrowablePut]] method (15.4.5.1).

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 behaviour of such operators as delete, typeof, and the assignment operators. For example, the left-hand operand of an assignment is expected to produce a reference. The behaviour 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. (Another reason not to use a syntactic case analysis is that it would be lengthy and awkward, affecting many parts of the specification.)

A Reference is a reference to a resolved name binding. A Reference consists of three components, the base value, the referenced name and the Boolean valued strict reference flag. The base value is either null, an object, or an environment record (10.2.1). A base value of null indicates that the reference could not be resolved to a binding. The referenced name is a string.

The following abstract operations are used in this specification to access the components of references:
8.7.1 GetValue (V)
1. If Type(V) is not Reference, return V.
2. Call GetBase(V).
3. If UnresolvableReference(V), throw a ReferenceError exception.
4. If IsPropertyReference(V), then
   a. Call the [[Get]] method of Result(2), passing GetReferencedName(V) for the argument.
   b. Return Result(4a).
5. Else, Result(2) must be an environment record.
   a. Call the GetBindingValue(N, V) concrete method of Result(2) passing GetReferencedName(V) and IsStrictReference(V) as arguments.
   b. Return Result(5a).

8.7.2 PutValue (V, W)
1. If Type(V) is not Reference, throw a ReferenceError exception.
2. Call GetBase(V).
3. If UnresolvableReference(V), then
   a. If IsStrictReference(V) is true, then throw a ReferenceError exception.
   b. Call the [[ThrowablePut]] method for the global object, passing GetReferencedName(V) for the property name, W for the value, and false for the Throw flag.
4. Else if IsPropertyReference(V), then
   a. Call the [[ThrowablePut]] method of Result(2), passing GetReferencedName(V) for the property name, W for the value, and IsStrictReference(V) for the Throw flag.
5. Else Result(2) must be a reference whose base is an environment record. So,
   a. Call the SetMutableBinding(N, V, S) concrete method of Result(2), passing GetReferencedName(V) for N, W for V, and IsStrictReference(V) for S.
6. 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 (see 11.2.4) 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 behaviour of statements (break, continue, return and throw) that perform nonlocal transfers of control. Values of the Completion type are triples of the form (type, value, target), where type is one of normal, break, continue, return, or throw, value is any ECMAScript value or empty, and target is any ECMAScript identifier or empty.

The term “abrupt completion” refers to any completion with a type other than normal.
8.10 The Property Descriptor and Property Identifier Types

The internal Property Descriptor and Property Identifier types are not language data types. They are defined by this specification purely for expository purposes. An implementation of ECMAScript must behave as if it produced and operated upon Property Descriptor and Property Identifier values in the manner described here. However, values of these types are used only as an intermediate result of expression evaluation and cannot be stored as the value of a variable or property.

The Property Descriptor type is used to explain the manipulation and reification of named property attributes. Values of the Property Descriptor type are records composed of named fields where each field’s name is an attribute name and its value is a corresponding attribute value. In addition, any field may be present or absent.

Property Descriptor values may be further classified as data property descriptors and accessor property descriptors based upon the existence or use of certain fields. A data property descriptor is one that includes any fields named either [[Value]], or [[Writable]]. An accessor property descriptor is one that includes any fields named either [[Getter]], or [[Setter]]. Any property descriptor may have fields named [[Enumerable]], and [[Configurable]].

For notational convenience within this specification, an object literal-like syntax can be used to define a property descriptor value. For example, Property Descriptor{value: 42, writable: false, configurable: true} defines a data property descriptor. The order of listing fields names is not significant. Any fields that are not explicitly listed are considered to be absent.

In specification text and algorithms, dot notation may be used to refer to a specific field of a Property Descriptor. For example, if D is a property descriptor then D.[[Value]] is short hand for “the field of D named “value””.

The Property Identifier type is used to associate a property name with a Property Descriptor. Values of the Property Identifier type are pairs of the form (name, descriptor), where name is a string and descriptor is a Property Descriptor value.

The following abstract operations are used in this specification to operate upon Property Descriptor values:

8.10.1 IsAccessorDescriptor (Desc)
When the abstract operation IsAccessorDescriptor is called with property descriptor Desc the following steps are taken:
1. If Desc is undefined, then return false
2. If both Desc.[[Getter]] and Desc.[[Setter]] are absent, then return false.
3. Return true

8.10.2 IsDataDescriptor (Desc)
When the abstract operation IsDataDescriptor is called with property descriptor Desc the following steps are taken:
1. If Desc is undefined, then return false.
2. If both Desc.[[Value]] and Desc.[[Writable]] are absent, then return false.
3. Return true.

8.10.3 IsGenericDescriptor (Desc)
When the abstract operation IsGenericDescriptor is called with property descriptor Desc the following steps are taken:
1. If Desc is undefined, then return false.
2. If IsAccessorDescriptor(Desc) and IsDataDescriptor(Desc) are both false, then return true.
3. Return false.

8.10.4 FromPropertyDescriptor (Desc)
When the abstract operation FromPropertyDescriptor is called with property descriptor Desc the following steps are taken; the following steps are taken:
1. If Desc is undefined, then return undefined.
2. Create a new object as if by the expression new Object() where Object is the standard built-in constructor with that name.
3. If IsDataDescriptor(Desc) is true, then
   a. Call the [[Put]] method of Result(2) with arguments “value” and Desc.[[Value]].
   b. Call the [[Put]] method of Result(2) with arguments “writable” and Desc.[[Writable]].

4. Else, IsAccessorDescriptor(Desc) must be true, so
   a. Call the [[Put]] method of Result(2) with arguments “getter” and Desc.[[Getter]].
   b. Call the [[Put]] method of Result(2) with arguments “setter” and Desc.[[Setter]].

5. Call the [[Put]] method of Result(2) with arguments “enumerable” and Desc.[[Enumerable]].
6. Call the [[Put]] method of Result(2) with arguments “configurable” and Desc.[[Configurable]].
7. Return Result(2).

NOTE
The above algorithm assumes that Desc is a fully populated Property Descriptor, such as that returned from [[GetOwnProperty]].

8.10.5 ToPropertyDescriptor (Desc)
When the abstract operation ToPropertyDescriptor is called with object Desc, the following steps are taken:
1. If Desc is undefined, then return undefined.
2. Call ToObject(Desc).
3. Create a new Property Descriptor that initially has no fields.
4. Call the [[HasProperty]] method of Result(2) with argument “enumerable”.
5. If Result(4) is true, then
   a. Call the [[Get]] method of Desc with “enumerable”.
   b. Call ToBoolean(Result(5a)).
   c. Set the [[Enumerable]] field of Result(3) to Result(5b).

6. Call the [[HasProperty]] method of Result(2) with argument “configurable”.
7. If Result(6) is true, then
   a. Call the [[Get]] method of Result(2) with argument “configurable”.
   b. Call ToBoolean(Result(7a)).
   c. Set the [[Configurable]] field of Result(3) to Result(7b).
8. Call the [[HasProperty]] method of Result(2) with argument “value”.
9. If Result(8) is true, then
   a. Call the [[Get]] method of Result(2) with argument “value”.
   b. Call IsCallable(Result(9a)).
   c. If Result(13b) is false and Result(13a) is not undefined, then throw a TypeError exception.
   d. Set the [[Value]] field of Result(3) to Result(13a).
10. Call the [[HasProperty]] method of Result(2) with argument “writable”.
11. If Result(10) is true, then
    a. Call the [[Get]] method of Result(2) with argument “writable”.
    b. Call ToBoolean(Result(11a)).
    c. Set the [[Writable]] field of Result(3) to Result(11b).
12. Call the [[HasProperty]] method of Result(2) with argument “getter”.
13. If Result(12) is true, then
    a. Call the [[Get]] method of Result(2) with argument “getter”.
    b. Call IsCallable(Result(13a)).
    c. If Result(13b) is false and Result(13a) is not undefined, then throw a TypeError exception.
    d. Set the [[Getter]] field of Result(3) to Result(13a).
14. Call the [[HasProperty]] method of Result(2) with argument “setter”.
15. If Result(14) is true, then
    a. Call the [[Get]] method of Result(2) with argument “setter”.
    b. Call IsCallable(Result(15a)).
    c. If Result(15b) is false and Result(15a) is not undefined, then throw a TypeError exception.
    d. Set the [[Setter]] field of Result(3) to Result(15a).
16. If either Result(3).[[Getter]] or Result(3).[[Setter]] are present, then
    a. If either Result(3).[[Value]] or Result(3).[[Writable]] are present, then throw a TypeError exception.
17. Return Result(3).

8.11 The Environment Record Type
TBD: Do we want to mention Environment Records here?
9 Type Conversion and Testing

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, List, Completion, or PropertyDescriptor (the internal types).

9.1 ToPrimitive

The operator ToPrimitive takes a Value argument and an optional argument PreferredType. The operator ToPrimitive converts 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 favour that type. Conversion occurs according to the following table:

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>The result equals the input argument (no conversion).</td>
</tr>
<tr>
<td>Null</td>
<td>The result equals the input argument (no conversion).</td>
</tr>
<tr>
<td>Boolean</td>
<td>The result equals the input argument (no conversion).</td>
</tr>
<tr>
<td>Number</td>
<td>The result equals the input argument (no conversion).</td>
</tr>
<tr>
<td>String</td>
<td>The result equals the input argument (no conversion).</td>
</tr>
<tr>
<td>Object</td>
<td>Return a default value for the Object. The default value of an object is retrieved by calling the internal [[DefaultValue]] method of the object, passing the optional hint PreferredType. The behaviour of the [[DefaultValue]] method is defined by this specification for all native ECMAScript objects (8.6.2.6).</td>
</tr>
</tbody>
</table>

9.2 ToBoolean

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

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

9.3 ToNumber and ToDecimal

The operator ToNumber and ToDecimal converts an argument to a value of type Number or type Decimal respectively, according to the following table:

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td></td>
</tr>
<tr>
<td>Null</td>
<td></td>
</tr>
<tr>
<td>Boolean</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td></td>
</tr>
<tr>
<td>String</td>
<td></td>
</tr>
<tr>
<td>Object</td>
<td></td>
</tr>
<tr>
<td>Undefined</td>
<td>NaN</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>Null</td>
<td>+0</td>
</tr>
<tr>
<td>Boolean</td>
<td>The result is 1 if the argument is true. The result is +0 if the argument is false.</td>
</tr>
<tr>
<td>Number</td>
<td>The result equals the input argument (no conversion).</td>
</tr>
<tr>
<td>String</td>
<td>See grammar and note below.</td>
</tr>
</tbody>
</table>
| 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 and ToDecimal 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.

```plaintext
StringNumericLiteral ::=  
  StrWhiteSpace_opt  
  StrWhiteSpace_opt  
  StrNumericLiteral  
  StrWhiteSpace_opt

StrWhiteSpace ::=  
  StrWhiteSpaceChar  
  StrWhiteSpaceopt

StrWhiteSpaceChar ::=  
  StrWhiteopt  
  LineTerminator

StrDecimalLiteral ::=  
  StrUnsignedDecimalLiteral

StrUnsignedDecimalLiteral ::=  
  Infinity  
  DecimalDigits  
  DecimalDigit  
  DecimalDigits  
  DecimalDigit  
  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
```

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SignedInteger ::=  
DecimalDigits  
+ DecimalDigits  
− DecimalDigits

HexStringLiteral ::=  
0x HexDigit  
OX HexDigit  
HexStringLiteral 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 (see 7.8.3):

- A StringNumericLiteral may be preceded and/or followed by white space and/or line terminators.
- 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 white space 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 (see 7.8.3), 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 as described below.

- The MV of StringNumericLiteral ::= [empty] is 0.
- The MV of StringNumericLiteral ::= StrWhiteSpace is 0.
- The MV of StringNumericLiteral ::= StrWhiteSpace, StrNumericLiteral, StrWhiteSpace is the MV of StrNumericLiteral, no matter whether white space is present or not.
- The MV of StrNumericLiteral ::= StrDecimalLiteral is the MV of StrDecimalLiteral.
- The MV of StrNumericLiteral ::= HexIntegerLiteral is the MV of HexIntegerLiteral.
- The MV of StrDecimalLiteral ::= + StrUnsignedDecimalLiteral is the MV of StrUnsignedDecimalLiteral.
- The MV of StrDecimalLiteral ::= − StrUnsignedDecimalLiteral is the negative of the MV of StrUnsignedDecimalLiteral. (Note that if the MV of StrUnsignedDecimalLiteral is 0, the negative of this MV is also 0. The rounding rule described below handles the conversion of this sign less mathematical zero to a floating-point +0 or −0 as appropriate.)
- The MV of StrUnsignedDecimalLiteral ::= Infinity is 10\(^{10000}\) (a value so large that it will round to +\(\infty\)).
- The MV of StrUnsignedDecimalLiteral :: DecimalDigits is the MV of DecimalDigits.
- The MV of StrUnsignedDecimalLiteral ::= DecimalDigits . DecimalDigits is the MV of the first DecimalDigits plus (the MV of the second DecimalDigits times 10\(^e\)), where n is the number of characters in the second DecimalDigits.
- The MV of StrUnsignedDecimalLiteral ::= DecimalDigits . ExponentPart is the MV of DecimalDigits times 10\(^e\), where e is the MV of ExponentPart.

The MV of StrUnsignedDecimalLiteral ::= DecimalDigits . DecimalDigits ExponentPart is (the MV of the first DecimalDigits plus (the MV of the second DecimalDigits times 10\(^e\))) times 10\(^n\), where n is the number of characters in DecimalDigits and e is the MV of ExponentPart.

The MV of StrUnsignedDecimalLiteral :: DecimalDigits is the MV of DecimalDigits times 10\(^n\), where n is the number of characters in DecimalDigits.

The MV of StrUnsignedDecimalLiteral :: 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 StrUnsignedDecimalLiteral :: DecimalDigits is the MV of DecimalDigits.
The MV of StrUnsignedDecimalLiteral::: 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 DecimalDigit :: 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.

Once the exact MV for a string numeric literal has been determined, it is then rounded to a value of the Number type or the Decimal type based on the operator used. If the MV is 0, then the rounded value is +0 unless the first non white space 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 8.5), unless the literal includes a StrUnsignedDecimalLiteral and the literal has more than 20 significant digits, in which case the number value may be either the number value for the MV of a literal produced by replacing each significant digit after the 20th with a 0 digit or the number value for the MV of a literal produced by replacing each significant digit after the 20th with a 0 digit and then incrementing the literal at the 20th digit position. A digit is significant if it is not part of an ExponentPart and it is not 0; or there is a nonzero digit to its left and there is a nonzero digit, not in the ExponentPart, to its right.

9.4 ToInteger

The operator ToInteger converts 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, +\(\infty\), or -\(\infty\), return Result(1).
4. Compute sign(Result(1)) \times floor(abs(Result(1))).
5. Return Result(4).

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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, $+0$, $-0$, $+\infty$, or $-\infty$, return $+0$.
3. Compute sign(Result(1)) * floor(abs(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 Result(4) - $2^{32}$, otherwise return Result(4).

NOTE
Given the above definition of ToInt32:
The ToInt32 operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.

$$\text{ToInt32}(\text{ToUint32}(x)) = \text{ToInt32}(x)$$

(To preserve this latter property that $+\infty$ and $-\infty$ are mapped to $+0$.)

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, $+0$, $-0$, $+\infty$, or $-\infty$, return $+0$.
3. Compute sign(Result(1)) * floor(abs(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).

NOTE
Given the above definition of ToUint32:

Step 5 is the only difference between ToUint32 and ToInt32.
The ToUint32 operation is idempotent: if applied to a result that it produced, the second application leaves that value unchanged.

$$\text{ToUint32}(\text{ToInt32}(x)) = \text{ToUint32}(x)$$

(To preserve this latter property that $+\infty$ and $-\infty$ are mapped to $+0$.)

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, $+0$, $-0$, $+\infty$, or $-\infty$, return $+0$.
3. Compute sign(Result(1)) * floor(abs(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).

NOTE
Given the above definition of ToUint16:
The substitution of $2^{16}$ for $2^{32}$ in step 4 is the only difference between ToUint32 and ToUint16.

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ToUint16 maps _0 to +0.

9.8 ToString

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

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>&quot;undefined&quot;</td>
</tr>
<tr>
<td>Null</td>
<td>&quot;null&quot;</td>
</tr>
<tr>
<td>Boolean</td>
<td>If the argument is true, then the result is &quot;true&quot;. If the argument is false, then the result is &quot;false&quot;.</td>
</tr>
<tr>
<td>Number</td>
<td>See note below.</td>
</tr>
<tr>
<td>String</td>
<td>Return the input argument (no conversion)</td>
</tr>
</tbody>
</table>
| 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 either the Number Type or the Decimal Type

The operator ToString converts a number \( m \) to string format as follows:

1. If \( m \) is NaN, return the string "NaN".
2. If \( m \) is +0 or -0, return the string "0".
3. If \( m \) is less than zero, return the string concatenation of the string "-" and ToString(-m).
4. If \( m \) is infinity, return the string "Infinity".
5. Otherwise, let \( n, k, \) and \( s \) be integers such that \( k \geq 1, 10^{k-1} \leq s < 10^k \), the number value for \( s \times 10^{-k} \) is \( m \), and \( k \) is as small as possible. Note that \( k \) is the number of digits in the decimal representation of \( s \), that \( s \) is not divisible by 10, and that the least significant digit of \( s \) is not necessarily uniquely determined by these criteria.
6. If \( 0 \leq n \leq 21 \), return the string consisting of the \( k \) digits of the decimal representation of \( s \) (in order, with no leading zeros), followed by \( n-k \) occurrences of the character '0'.
7. If \( 0 < n \leq 21 \), return the string consisting of the most significant \( n \) digits of the decimal representation of \( s \), followed by a decimal point '.', followed by the remaining \( k-n \) digits of the decimal representation of \( s \).
8. If \( -10 < n \leq 0 \), return the string consisting of the character '0', followed by a decimal point '.', followed by \( n \) occurrences of the character '0', followed by the \( k \) digits of the decimal representation of \( s \).
9. Otherwise, if \( k = 1 \), return the string consisting of the single digit of \( s \), followed by lowercase character 'e', followed by a plus sign '+' or minus sign '-' according to whether \( n-1 \) is positive or negative, followed by the decimal representation of the integer abs(n-1) (with no leading zeros).
10. Return the string consisting of the most significant digit of the decimal representation of \( s \), followed by a decimal point '.', followed by the remaining \( k-1 \) digits of the decimal representation of \( s \), followed by the lowercase character 'e', followed by a plus sign '+' or minus sign '-' according to whether \( n-1 \) is positive or negative, followed by the decimal representation of the integer abs(n-1) (with no leading zeros).

NOTE

The following observations may be useful as guidelines for implementations, but are not part of the normative requirements of this Standard:

- If \( x \) is any number value other than NaN, then ToNumber(ToString(x)) is exactly the same number value as \( x \).
- The least significant digit of \( s \) is not always uniquely determined by the requirements listed in step 5.

For implementations that provide more accurate conversions than required by the rules above, it is recommended that the following alternative version of step 5 be used as a guideline:
Otherwise, let \( n, k, \) and \( s \) be integers such that \( k \geq 1, \ 10^k \leq s < 10^k \), the number value for \( s \geq 10^k \) is \( m \), and \( k \) is as small as possible. If there are multiple possibilities for \( s \), choose the value of \( s \) for which \( s \geq 10^k \) is closest in value to \( m \). If there are multiple possibilities for \( s \) that are closest in value to \( m \), choose the one that is even. Note that \( k \) is the number of digits in the decimal representation of \( s \) and that \( s \) is not divisible by 10.

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


9.9 ToObject

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

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>Throw a TypeError exception.</td>
</tr>
<tr>
<td>Null</td>
<td>Throw a TypeError exception.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Create a new Boolean object whose [[PrimitiveValue]] property is set to the value of the boolean. See 15.6 for a description of Boolean objects.</td>
</tr>
<tr>
<td>Number</td>
<td>Create a new Number object whose [[PrimitiveValue]] property is set to the value of the number. See 15.7 for a description of Number objects.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Create a new Decimal object whose [[PrimitiveValue]] property is set to the value of the decimal. See 15.7 for a description of Decimal objects.</td>
</tr>
<tr>
<td>String</td>
<td>Create a new String object whose [[PrimitiveValue]] property is set to the value of the string. See 15.5 for a description of String objects.</td>
</tr>
<tr>
<td>Object</td>
<td>The result is the input argument (no conversion).</td>
</tr>
</tbody>
</table>

9.10 IsCallable

The operator IsCallable determines if its argument is a callable function Object according to the following table:

<table>
<thead>
<tr>
<th>Input Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>Return false.</td>
</tr>
<tr>
<td>Null</td>
<td>Return false.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Return false.</td>
</tr>
<tr>
<td>Number</td>
<td>Return false.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Return false.</td>
</tr>
<tr>
<td>String</td>
<td>Return false.</td>
</tr>
<tr>
<td>Object</td>
<td>If the argument object has an internal [[Call]] method, then return true, otherwise return false.</td>
</tr>
</tbody>
</table>

9.11 The SameValue Algorithm

The internal comparison function SameValue(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), return false.
2. If Type(x) is Undefined, return true.
3. If Type(x) is Null, return true.
4. If Type(x) is Number, then,
   a. If x is NaN and y is NaN, return true.
   b. If x is +0 and y is 0, return false.
   c. If x is 0 and y is +0, return false.
   d. If x is the same number value as y, return true.
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5. 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.

6. If Type(x) is Boolean, return true if x and y are both true or both false; otherwise, return false.

7. If Type(x) is Decimal, then
   a. If x is a Decimal NaN and y is a Decimal NaN then return true.
   b. If x is a Decimal positive zero and y is a Decimal negative zero, return false.
   c. If x is a Decimal negative zero and y is a Decimal positive zero, return false.
   d. Return the result of IEEE 754-2008 Decimal.compareQuietEqual(x, y).

8. Return true if x and y refer to the same object. Otherwise, return false.

10 Executable Code and Execution Contexts

10.1 Types of Executable Code

There are three types of ECMAScript executable code:

Global code is source text that is treated as an ECMAScript Program. The global code of a particular Program does not include any source text that is parsed as part of a FunctionBody.

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 ECMAScript Program. 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 parsed as part of a FunctionBody. The function code of a particular FunctionBody does not include any source text that is parsed as part of a nested FunctionBody. Function code also denotes the source text supplied when using the built-in Function object as a constructor. More precisely, the last parameter provided to the Function constructor is converted to a string and treated as the FunctionBody. If more than one parameter is provided to the Function constructor, all parameters except the last one are converted to strings and concatenated together, separated by commas. The resulting string is interpreted as the FormalParameterList for the FunctionBody defined by the last parameter. The function code for a particular instantiation of a Function does not include any source text that is parsed as part of a nested FunctionBody.

10.1.1 Strict Mode Code

As described in section 4.2.2, an ECMAScript Program syntactic unit may be processed using either unrestricted or strict mode syntax and semantics. When processed using strict mode the three types of ECMAScript code are referred to as strict global code, strict eval code, and strict function code. Code is interpreted in strict mode code in the following situations:

- Global code is strict global code if the Program that defines the global code includes a UseStrictDirective.
- Eval code is strict eval code if the Program that defines the eval code includes a UseStrictDirective or if the call to eval is a direct call (see section 15.1.2.1) to the eval function that is contained in strict mode code.
- Function code that is part of a FunctionDeclaration or FunctionExpression is strict function code if its FunctionDeclaration or FunctionExpression is contained in strict mode code or if its FunctionBody includes a UseStrictDirective.
- Function code that is supplied as the last argument to the built-in Function constructor is strict function code if the last argument is a string that when processed as a FunctionBody includes a UseStrictDirective.

10.2 Lexical Environments

A lexical environment is used to define the association of Identifiers to specific variables and functions based upon the lexical nesting structure of ECMAScript code. A lexical environment consists of an environment record and a possibly null reference to an outer lexical environment. Usually a lexical environment is associated with some specific syntactic structure of ECMAScript code such as a
FunctionDeclaration, a WithStatement, or a Block and a new lexical environment is created each time such code is evaluated.

An environment record records the identifier bindings that are created within the scope of its associated lexical environment.

The outer environment reference is used to model the dynamic nesting of lexical environments. The outer reference of a (inner) lexical environment is a reference to the lexical environment that logically surrounds the inner lexical environment. An outer lexical environment may, of course, have its own outer lexical environment. A lexical environment may serve as the outer environment for multiple inner lexical environments. For example, if a FunctionDeclaration contains two nested FunctionDeclarations then the lexical environments of each of the nested functions will have as their outer lexical environment the lexical environment of the current execution of the surrounding function.

Lexical environments and environment records are purely specification mechanisms and need not correspond to any particular artifact of an ECMAScript implementation. It is impossible for an ECMAScript program to directly access or manipulate them.

10.2.1 Environment Records

There are two kinds of environment records used in this specification: declarative environment records and object environment records. Declarative environment records are used to define the effect of ECMAScript language syntactic elements such as FunctionDeclarations, VariableDeclarations, and Catch clauses that directly associate identifier bindings with values or variables. Object environment records are used to define the effect of ECMAScript elements such as Program and WithStatement that associate identifier bindings with the properties of some object.

For specification purposes environment records can be thought of as existing in a simple object-oriented hierarchy where environment record is an abstract class with two concrete subclasses, declarative environment record and object environment record. The abstract class defines the following abstract methods that have distinct concrete definitions for each of its subclasses:

<table>
<thead>
<tr>
<th>Method</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>HasBinding(N)</td>
<td>Determine if an environment record has a binding for an identifier. Return true if it does and false if it does not. The string value N is the text of the identifier.</td>
</tr>
<tr>
<td>CreateMutableBinding(N)</td>
<td>Create a new mutable binding in an environment record. The string value N is the text of the bound name.</td>
</tr>
<tr>
<td>CreateImmutableBinding(N)</td>
<td>Create a new but uninitialized immutable binding in an environment record. The string value N is the text of the bound name.</td>
</tr>
<tr>
<td>GetBindingValue(N,S)</td>
<td>Returns the value of an already existing binding from an environment record. The string value N is the text of the bound name. If S is true and the binding is an uninitialized immutable binding throw a ReferenceError exception.</td>
</tr>
<tr>
<td>InitializeImmutableBinding(N,V)</td>
<td>Set the value of an already existing but uninitialized immutable binding in an environment record. The string value N is the text of the bound name. V is the value for the binding and is either a primitive value or an object.</td>
</tr>
<tr>
<td>SetMutableBinding(N,V, S)</td>
<td>Set the value of an already existing mutable binding in an environment record. The string value N is the text of the bound name. V is the value for the binding and is either a primitive value or an object. If S is true and the binding can not be set throw a TypeError exception.</td>
</tr>
</tbody>
</table>

10.2.1.1 Declarative Environment Records

Each declarative environment record is associated with a ECMAScript program scope containing variable, function, or constant declarations. A declarative environment record binding the set of identifiers defined by the declarations contained within its scope.
10.2.1.1 HasBinding(N)
The concrete environment record method HasBinding for declarative environment records simply determines if the argument identifier is one of the identifiers bound by the record:
1. Get the declarative environment record for which the method was invoked.
2. If Result(1) has a binding for the name that is the value of N, return true.
3. If it does not have such a binding, return false

10.2.1.2 CreateMutableBinding (N)
The concrete environment record method CreateMutableBinding for declarative environment records creates a new mutable binding for the name N that is initialized to the value undefined. A binding must not already exist in this environment record for N.
1. Get the declarative environment record for which the method was invoked.
2. Assert: Result(1) does not already have a binding for N.
3. Create a mutable binding in Result(1) for N and set its bound value to undefined.

10.2.1.3 CreateImmutableBinding (N)
The concrete environment record method CreateImmutableBinding for declarative environment records creates a new immutable binding for the name N that is initialized to the value undefined. A binding must not already exist in this environment record for N.
1. Get the declarative environment record for which the method was invoked.
2. Assert: Result(1) does not already have a binding for N.
3. Create an immutable binding in Result(1) for N and record that it is uninitialized.

10.2.1.4 GetBindingValue(N,S)
The concrete environment record method GetBindingValue for declarative environment records simply returns the value of its bound identifier whose name is the value of the argument N. The binding must already exist. If S is true and the binding is an unitialized immutable binding throw a ReferenceError exception.
1. Get the declarative environment record for which the method was invoked.
2. Assert: Result(1) has a binding for N.
3. If the binding for N in Result(1) is an uninitialized immutable binding, then
   a. If S is false, return the value undefined, otherwise throw a ReferenceError exception.
4. Else, return the value currently bound to N in Result(1).

10.2.1.5 InitializeImmutableBinding (N,V)
The concrete environment record method InitializeImmutableBinding for declarative environment records is used to set the bound value of the current binding of the identifier whose name is the value of the argument N to the value of argument V. A uninitialized immutable binding for N must already exist.
1. Get the declarative environment record for which the method was invoked.
2. Assert: Result(1) must have an unitialized immutable binding for N.
3. Set the bound value for N in Result(1) to V.
4. Record that the immutable binding for N in Result(1) has been initialized.

10.2.1.6 SetMutableBinding (N,V,S)
The concrete environment record method SetMutableValue for declarative environment records attempts to change the bound value of the current binding of the identifier whose name is the value of the argument N to the value of argument V. A binding for N must already exist. If the binding is an immutable binding, A TypeError is always thrown. The S argument is ignored because strict mode does not change the meaning of setting bindings in declarative environment records have .
1. Get the declarative environment record for which the method was invoked.
2. Assert: Result(1) must have a binding for N.
3. If the binding for N in Result(1) is a mutable binding, change its bound value to V.
4. Else this must be an attempt to change the value of an immutable binding so throw a TypeError exception.
10.2.1.2 Object Environment Records

Each object environment record is associated with an object called its binding object. An environment record binds the set of identifiers that directly correspond to the property names of its binding object. Property names that are not identifiers are not included in the set of bound identifiers. Because properties can be dynamically added and deleted from objects, the set of identifiers bound by an object environment record may potentially change as a side-effect of any operation that adds or deletes properties. Any bindings that are created as a result of such a side-effect is considered to be a mutable binding even if the Writable attribute of the corresponding property has the value false. Immutable bindings can only be defined using the CreateImmutableBinding method.

10.2.1.2.1 HasBinding(N)

The concrete environment record method HasBinding for object environment records determines if its associated binding object has a property whose name is the value of the argument N:

1. Get the object environment record for which the method was invoked.
2. Get the binding object for Result(1).
3. Call the [[HasProperty]] method of Result(2), passing N as the property name.
4. Return Result(3).

10.2.1.2.2 CreateMutableBinding (N)

The concrete environment record method CreateMutableBinding for object environment records creates a property named N in the environment record that is initialized to the value undefined. A property named N must not already exist in the binding object.

1. Get the declarative environment record for which the method was invoked.
2. Get the binding object for Result(1).
3. Assert: The result of calling the [[HasProperty]] method of Result(2), passing N as the property name is false.
4. Call the [[Put]] method of Result(2), passing N and undefined for the arguments.

10.2.1.2.3 CreateImmutableBinding (N)

The concrete environment record method CreateImmutableBinding for object environment records creates a new immutable binding for the name N that is initialized to the value undefined. A binding must not already exist in this environment record for N.

1. Get the declarative environment record for which the method was invoked.
2. Get the binding object for Result(1).
3. Assert: The result of calling the [[HasProperty]] method of Result(2), passing N as the property name is false.
4. Call the [[DefineOwnProperty]] method of Result(2), passing N, the property descriptor {[[Value]]: undefined, [[Writable]]: false, [[Enumerable]]: true, [[Configurable]]: true}, and false as arguments.
5. Record that the binding in Result(1) for N is uninitialized.

10.2.1.2.4 GetBindingValue(N,S)

The concrete environment record method GetBindingValue for object environment records returns the value of it’s associated binding object’s property whose name is the value of the argument identifier. The property should already exist but it does not the result depends upon the value of S argument:

1. Get the object environment record for which the method was invoked.
2. Get the binding object for Result(1).
3. Call the [[HasProperty]] method of Result(2), passing N as the property name.
4. If Result(3) is false or the binding for N in Result(1) is an uninitialized immutable binding, then
   a. If S is false, return the value undefined, otherwise throw a ReferenceError excepton.
5. Call the [[Get]] method of Result(2), passing N for the argument.
6. Return Result(5)
10.2.1.2.5 InitializeImmutableBinding (N,V)

The concrete environment record method InitializeImmutableBinding for object environment records is used to set the value of its associated binding object's property whose name is the value of the argument N to the value of argument V. A uninitialized immutable binding for N must already exist.

1. Get the declarative environment record for which the method was invoked.
2. Get the binding object for Result(1).
3. Assert: The result of calling the [[HasProperty]] method of Result(2), passing N as the property name is true.
4. Call the [[DefineOwnProperty]] method of Result(2), passing N, the property descriptor {[[Value]]: V, [[Writable]]: false}, and false as arguments.
5. Record that the immutable binding for N in Result(1) has been initialized.

10.2.1.2.6 SetMutableBinding (N,V,S)

The concrete environment record method SetMutableValue for object environment records attempts to set the value of the environment record’s associated binding object’s property whose name is the value of the argument N to the value of argument V. A property named N should already exist but if it does not or is not currently writable, error handling is determined by the value of the Boolean argument S.

1. Get the object environment record for which the method was invoked.
2. Get the binding object for Result(1).
3. If the binding for N in Result(1) is a mutable binding, then
   a. Call the [[ThrowablePut]] method of Result(2) with arguments N, V, and S.
4. Else this must be an attempt to change the value of an immutable binding so throw a TypeError exception.

10.2.2 Lexical Environment Operations

The following abstract operations are used in this specification to operate upon lexical environments:

10.2.2.1 GetIdentifierReference (lex, name, strict)

When the abstract operation GetIdentifierReference is called with a lexical environment lex, identifier string name, and boolean flag strict the following steps are performed:

1. Let env be the value of lex.
2. While env is not null, repeat
   a. Let envRec be env’s environment record.
   b. Call the HasBinding(N) concrete method of envRec passing name as the argument N.
   c. If Result(2b) is true, return a value of type Reference whose base value is envRec, whose referenced name is name, and whose strict mode flag is strict.
   d. Else, set env to the value of the current env’s outer environment reference.
3. name does not have a binding in the lexical environment lex, so return a value of type Reference whose base value is null, whose referenced name is name, and whose strict mode flag is strict.

10.2.2.2 NewDeclarativeEnvironmentRecord(E)

When the abstract operation NewDeclarativeEnvironmentRecord is called with either a lexical environment or null as argument E the following steps are performed:

1. Create a new DeclarativeEnvironmentRecord containing no bindings.
2. Set the outer lexical environment reference of Result(1) to E.
3. Return Result(1).

10.2.2.3 NewObjectEnvironmentRecord(O,E)

When the abstract operation NewObjectEnvironmentRecord is called with object O as an argument and a lexical environment or null as argument E the following steps are performed:

1. Create a new ObjectEnvironmentRecord containing using O is the binding object.
2. Set the outer lexical environment reference of Result(1) to E.
3. Return Result(1).

10.2.2.4 PopEnvironmentRecord

When the abstract operation PopEnvironmentRecord is called the following steps are performed:

Comment [pL17]: From AWB:
This depends upon DefineOwnProperty’s ability to reset the value of a “readonly” data property.
1. Get the outer lexical environment reference of the current LexicalEnvironment.
2. Set the LexicalEnvironment to Result(1).

10.2.3 The Global Environment

The global environment is a unique lexical environment which is created before any ECMAScript code is executed. The global environment’s environment record is an object environment record whose binding object is the global object (15.1). The global environments’s outer environment is null.

As ECMAScript code is executed, additional properties may be added to the global object and the initial properties may be modified.

10.3 Execution Contexts

When control is transferred to ECMAScript executable code, 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. A new execution context is created whenever control is transferred from the executable code associated with the currently running execution context to executable code that is not associated with that execution context. The newly created execution context is pushed onto the stack and becomes the running execution context.

An execution context contains whatever state is necessary to tract the execution progress of its associated code. In addition, each execution context has the following state components:

<table>
<thead>
<tr>
<th>Component</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>LexicalEnvironment</td>
<td>Identifies the lexical environment used to resolve identifier references made by code within this execution context.</td>
</tr>
<tr>
<td>VariableEnvironment</td>
<td>Identifies the environment record that holds bindings created by VariableStatements and FunctionDeclarations within the execution context.</td>
</tr>
<tr>
<td>ThisBinding</td>
<td>The value associated with the this keyword within ECMAScript code associated with this execution context.</td>
</tr>
</tbody>
</table>

The LexicalEnvironment and VariableEnvironment components of an execution context are always lexical environments. When a execution context is created its LexicalEnvironment and VariableEnvironment components have the same value. The value of the VariableEnvironment component never changes while the value of the LexicalEnvironment component may change during execution of code within an execution context.

In most situations only the running execution context (the top of the execution context stack) is directly manipulated by algorithms within this specification. Hence when the terms “LexicalEnvironment”, “VariableEnvironment” and “ThisBinding” are used without qualification they are in reference to those components of the running execution context.

An execution context is purely a specification mechanism and need not correspond to any particular artefact of an ECMAScript implementation. It is impossible for an ECMAScript program to access an execution context.

10.3.1 Identifier Resolution

Identifier resolution is process of determining the binding of an Identifier using the LexicalEnvironment of the running execution context. During execution of ECMAScript code, the syntactic production PrimaryExpression : Identifier is evaluated using the following algorithm:

1. Let env be the running execution context’s LexicalEnvironment.
2. If the syntactic production that is being evaluated is contained in a strict mode code, then let strict be true else let strict be false.
3. Call the abstract operation GetIdentifierReference function passing env, Identifier, and strict as arguments.
4. Return Result(3).

The result of evaluating an identifier is always a value of type Reference with its referenced name component equal to the Identifier string.
10.3.2 Arguments Object

When control enters an execution context for function code, an arguments object is created.

The arguments object is created by calling the abstract operation CreateArgumentsObject with arguments `func` the function object whose code is to be evaluated, `names` a List containing the formal parameter names, `args` the actual arguments pass to the `[[Call]]` method, `env` the variable environment for the function code, and `strict` a Boolean that indicates whether or not the function code is strict code. When CreateArgumentsObject is call the following steps are performed:

If `strict` is `true`, perform the following steps:

1. Let `len` be the number of elements in `args`.
2. Create a new object as if by the expression `new Array(len)` where `Array` is the standard built-in constructor with that name and `len` is the numeric value of `len`.
3. Let `obj` be Result(2).
4. Let `indx` = 0
5. Repeat while `indx` < `len`.
   a. Let `val` be the the element of `args` at 0-originated list position `indx`.
   b. Call the `[[Put]]` method of `obj` passing `indx` and `val` as arguments.
   c. Let `indx` = `indx` + 1
6. Let `f` be a function which when evaluated throws a `TypeError` exception and performs no other actions.
7. Call the `[[DefineOwnProperty]]` method on `obj` passing "callee", the property descriptor `[[Getter]]`: `f`, `[[Enumerable]]`: `false`, `[[Configurable]]`: `false`, and `true` as arguments.
8. Call the `[[DefineOwnProperty]]` method on `obj` passing "callee", the property descriptor `[[Getter]]`: `f`, `[[Enumerable]]`: `false`, `[[Configurable]]`: `false`, and `true` as arguments.
9. Return `obj`

If `strict` is `false`, perform the following steps:

1. Let `len` be the number of elements in `args`.
2. Create a new ECMAScript object.
3. Let `obj` be Result(2).
4. Set the `[[Class]]` property of `obj` to "Object".
5. Set the `[[Constructor]]` property of `obj` to the standard built-in Object constructor (Section 15.2.3).
6. Set the `[[Prototype]]` property of `obj` to the standard built-in Array prototype object (Section 15.4.4).
7. Call the `[[DefineOwnProperty]]` method on `obj` passing "length", the property descriptor `[[Value]]`: `len`, `[[Enumerable]]`: `false`, `[[Configurable]]`: `true`, and `false` as arguments.
8. Let `indx` = 0
9. Repeat while `indx` < `len`.
   a. If `indx` is less than the number of elements in `names`, then
      i. Let `name` be the the element of `names` at 0-originated list position ` indx`.
      ii. Let `g` be the result of calling the MakeArgGetter function with arguments `name` and `env`.
      iii. Let `p` be the result of calling the MakeArgSetter function with arguments `name` and `env`.
      iv. Call the `[[DefineOwnProperty]]` method on `obj` passing ToString(`indx`), the property descriptor `[[Setter]]`: `p`, `[[Getter]]`: `g`, `[[Enumerable]]`: `false`, `[[Configurable]]`: `true`, and `false` as arguments.
   b. Else, there are fewer arg names than actual arguments so
      i. Let `val` be the the element of `args` at 0-originated list position `indx`.
      ii. Call the `[[Put]]` method of `obj` passing `indx` and `val` as arguments.
   c. Let `indx` = `indx` + 1
10. Call the `[[DefineOwnProperty]]` method on `obj` passing "callee", the property descriptor `[[Value]]`: `func`, `[[Enumerable]]`: `false`, `[[Configurable]]`: `true`, and `false` as arguments.
11. Return `obj`

The function MakeArgGetter called with string `name` and environment record `env` creates a function object that when executes returns the value bound for `name` in `env`. It performs the following steps:
1. Let body be the result of concatenating the strings "return", name, and ";"
2. Create a function object as described in 13.2 using no FormalParameterList, body for FunctionBody, and env as Scope.
3. Return Result(2)

The function MakeArgSetter called with string name and environment record env creates a function object that when executes returns the value bound for name in env. It performs the following steps:

1. Let param be the string name concatenated with the string ",_arg"
2. Let body be the string "<name> = <param>;" with <name> replaced by the value of name and <param> replaced by the value of param.
3. Create a function object as described in 13.2 using a List containing the single string param as FormalParameterList, body for FunctionBody, and env as Scope.
4. Return Result(3).

10.3.2.1 Strict Mode Restrictions
If a arguments object is created, a callee property is not created.

The arguments object does not share properties with the activation object. Changing the value of a arguments object property does not change the value of the corresponding activation object property and vice versa.

10.3.3 Declaration Binding Instantiation
Every execution context has associated with it an environment record that provides the VariableEnvironment for that execution context. Variables and functions declared in ECMAScript code evaluate in the execution context are added as bindings in the that environment record. For function code, parameters are also added as bindings.

Which environment record is used to bind declaration and its kind depends on the type of ECMAScript code executed by the execution context, but the remainder of the behaviour is generic. On entering an execution context, bindings are created in the VariableEnvironment environment record as follows:

1. Let env be the running execution context's VariableEnvironment.
2. If the ECMAScript code that is to be executed is strict mode code, then let strict be true else let strict be false.
3. If the code that is to be executed is eval code, let eval be true, otherwise false.
4. If the code that is to be executed is function code, then
   a. Let names be a list containing, in left to right order, the strings corresponding to the identifiers of the function's FormalParameterList.
   b. Let args be the argument list passed to the [[Call]] internal method that is executing the function code and let argCount be the number of elements in args.
   c. Let func be the function object that is the this value of the [[Call]] internal method that is executing the function code.
   d. Let n be the number 0.
   e. For each string argName in names, in list order do
      i. Let n be the current value of n plus 1.
      ii. If n is greater than the number of elements in args, let v be undefined otherwise let v be the n'th element in args.
      iii. Call env's HasBinding(N) concrete method passing argName as the argument.
      iv. If Result(4eiii) is false, Call env's CreateMutableBind(N) concrete method passing argName as the argument.
      v. Call env's SetMutableBinding(N,V,S) concrete method passing argName, v, and strict as the arguments.
5. For each FunctionDeclaration f in the execution context's code, in source text order do
   a. Let fn be the Identifier in FunctionDeclaration f.
   b. Let fo be the result of creating a function object as described in section 13 using env as the [[Scope]].
   c. Call env's HasBinding(N) concrete method passing fn as the argument.
   d. If Result(5c) is false, Call env's CreateMutableBind(N) concrete method passing fn as the argument.

Comment [pL20]: From AWB: Remember to put strict mode duplicate name checks into function declaration parsing.
The initial LexicalEnvironment is defined, then the string determined.

When control enters an execution context, the execution context’s ThisBinding is set, its VariableEnvironment is set, and the this value is determined. The exact manner in which these actions occur depend on the type of code being entered.

10.4 Entering An Execution Context

Every function and constructor call enters a new execution context, even if a function is calling itself recursively. Every return exits an execution context. A thrown exception may also exit one or more execution contexts.

When control enters an execution context, the execution context’s ThisBinding is set, its VariableEnvironment is defined, and instantiation is performed, and the this value is determined. The exact manner in which these actions occur depend on the type of code being entered.

10.4.1 Global Code

The following sets are performed when control enters the execution context for global code:

1. Set the VariableEnvironment to the Global Environment.
2. Set the LexicalEnvironment to the Global Environment.
3. If the code is strict code, set the ThisBinding to the global object, otherwise set the ThisBinding to undefined.
4. Perform DeclarationBindingInstantiation using the global code.

10.4.2 Eval Code

The following sets are performed when control enters the execution context for eval code:

1. If there is no calling context or if the eval code is not being evaluated by a direct call (Section 15.1.2.1) apply the steps in section 10.4.1 using the eval code as the global code.
2. Else,
   a. Set the ThisBinding to the same value as the ThisBinding of the calling context.
   b. If the eval code is strict code, then
      i. Call env’s CreateMutantBinding(N, V) concrete method passing fn, fo, and strict as the arguments.
      ii. Call env’s SetMutableBinding(N, V, S) concrete method passing dn, undefined, and strict as the arguments.
   c. Else,
      i. Call env’s CreateMutableBinding(N) concrete method passing dn as the argument.
      ii. Call env’s SetMutableBinding(N, V, S) concrete method passing dn, undefined, and strict as the arguments.
   d. Else if strict is true and eval is true throw an EvalError exception.

6. For each VariableDeclaration and VariableDeclarationNoIn dn in the execution context’s code, in source text order do
   a. Let dn be the Identifier in d.
   b. Call env’s HasBinding(N) concrete method passing dn as the argument.
   c. If Result(6d) is false, then
      i. Call env’s CreateMutableBinding(N) concrete method passing dn as the argument.
      ii. Call env’s SetMutableBinding(N, V, S) concrete method passing dn, undefined, and strict as the arguments.
   d. Else if strict is true and eval is true throw an EvalError exception.

7. Call env’s HasBinding(N) concrete method passing "arguments" as the argument

8. If the code is function code and Result(7) is false, then
   a. Call the abstract operation CreateArgumentsObject passing func, names, args, env and strict as arguments.
   b. If strict is true, then
      i. Call env’s CreateImmutableBinding(N) concrete method passing the string "arguments" as the argument.
      ii. Call env’s InitializeImmutableBinding(N, V, S) concrete method passing "arguments" and Result(8a) as arguments.
   c. Else,
      i. Call env’s CreateMutableBinding(N, D) concrete method passing the string "arguments" and false as the arguments.
      ii. Call env’s SetMutableBinding(N, V, S) concrete method passing "arguments", Result(8a), and strict as arguments.

3. Perform Declaration Binding Instantiation using eval code.

10.4.2.1 Strict Mode Restrictions

If either the execution context for the eval code or the execution context in which the eval operator
was executed is subset restricted to the strict subset, the eval code cannot instantiate variables,
functions, or constants in the lexical environment of the context that invoked the eval operator.

Instead, a new environment object is created and appended to the head of the calling context’s scope
chain and that environment object is used for environment bindings instantiation of the eval code.

10.4.3 Function Code

The following sets are performed when control enters the execution context for function code contained
in function object F:

1. Let thisArg be the caller provided this value.
2. If the function code is strict code, set the ThisBinding to thisArg.
3. Else if thisArg is null or undefined, set the ThisBinding to the global object.
4. Else if thisArg is not an object, set the ThisBinding to ToObject(thisArg).
5. Else set the ThisBinding to thisArg.
6. Call NewDeclarativeEnvironmentRecord(E) passing the value of the [[Scope]] property of F as the
   argument.
7. Set the LexicalEnvironment to Result(6).
8. Set the VariableEnvironment to the same value as the LexicalEnvironment.
9. Perform Declaration Binding Instantiation using the function code of F.

11 Expressions

11.1 Primary Expressions

Syntax

PrimaryExpression :  
  this
  Identifier
  Literal
  ArrayLiteral
  ObjectLiteral
  ( 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 10.3.1. The result of evaluating an Identifier
is always a value of type Reference.

11.1.3 Literal Reference

A Literal is evaluated as described in 7.8.

11.1.4 Array Initialiser

An array initialiser is an expression describing the initialisation of an Array object, written in a form of a
literal. It is a list of zero or more expressions, each of which represents an array element, enclosed in
square brackets. The elements need not be literals; they are evaluated each time the array initialiser is
evaluated.

Array elements may be elided at the beginning, middle or end of the element list. Whenever a comma in
the element list is not preceded by an AssignmentExpression (i.e., a comma at the beginning or after
another comma), the missing array element contributes to the length of the Array and increases the index
of subsequent elements. Elided array elements are not defined. If an element is elided at the end of an
array, that element does not contribute to the length of the Array.

Syntax
ArrayLiteral:
  [ Elision_opt ]
  [ ElementList ]
  [ ElementList, Elision_opt ]

ElementList:
  Elision_opt AssignmentExpression
  ElementList, Elision_opt AssignmentExpression

Elision:
  ,
  Elision

Semantics

The production `ArrayLiteral : [ Elision_opt ]` is evaluated as follows:
1. Create a new `object` as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name.
2. Evaluate `Elision`; if not present, use the numeric value zero.
3. Call the `[[Put]]` method of Result(1) with arguments “`length`” and Result(2).
4. Return Result(1).

The production `ArrayLiteral : [ ElementList ]` is evaluated as follows:
1. Evaluate `ElementList`.
2. Return Result(1).

The production `ArrayLiteral : [ ElementList, Elision_opt ]` is evaluated as follows:
1. Evaluate `ElementList`.
2. Evaluate `Elision`; if not present, use the numeric value zero.
3. Call the `[[Get]]` method of Result(1) with argument “`length`”.
4. Call the `[[Put]]` method of Result(1) with arguments “`length`” and (Result(2)+Result(3)).
5. Return Result(1).

The production `ElementList : Elision_opt AssignmentExpression` is evaluated as follows:
1. Create a new `object` as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name.
2. Evaluate `Elision`; if not present, use the numeric value zero.
3. Evaluate `AssignmentExpression`.
4. Call `GetValue(Result(3))`.
5. Call the `[[Put]]` method of Result(1) with arguments Result(2) and Result(4).
6. Return Result(1)

The production `ElementList : ElementList, Elision_opt AssignmentExpression` is evaluated as follows:
1. Evaluate `ElementList`.
2. Evaluate `Elision`; if not present, use the numeric value zero.
3. Evaluate `AssignmentExpression`.
4. Call `GetValue(Result(3))`.
5. Call the `[[Get]]` method of Result(1) with argument “`length`”.
6. Call the `[[Put]]` method of Result(1) with arguments (Result(2)+Result(5)) and Result(4).
7. Return Result(1)

The production `Elision : ,` is evaluated as follows:
1. Return the numeric value 1.

The production `Elision : Elision` is evaluated as follows:
Evaluate Elision.
2. Return (Result(1)+1).

NOTE:
The use of [[Put[]]] rather than [[ThrowablePut[]]] in this section is intentional as there are no situations where these [[Put[]]] operations should fail.

11.1.5 Object Initialiser
An object initialiser is an expression describing the initialisation of an Object, written in a form resembling a literal. It is a list of zero or more pairs of property names and associated values, enclosed in curly braces. The values need not be literals; they are evaluated each time the object initialiser is evaluated.

Syntax

ObjectLiteral :
{ } { PropertyNameAndValueList } { PropertyNameAndValueList , }

PropertyNameAndValueList :
PropertyAssignment
PropertyNameAndValueList , PropertyAssignment

PropertyAssignment :
PropertyName : AssignmentExpression
  get PropertyName () { FunctionBody }
  set PropertyName ( PropertySetParameterList ) { FunctionBody }

PropertyName :
IdentifierName
StringLiteral
NumericLiteral

PropertySetParameterList :
Identifier

Semantics
The production ObjectLiteral : { } is evaluated as follows:
1. Create a new object as if by the expression new Object() where Object is the standard built-in constructor with that name.
2. Return Result(1).

The productions ObjectLiteral : { PropertyNameAndValueList } and { PropertyNameAndValueList , } are evaluated as follows:
1. Evaluate PropertyNameAndValueList.
2. Return Result(1);

The production PropertyNameAndValueList : PropertyAssignment is evaluated as follows:
1. Create a new object as if by the expression new Object() where Object is the standard built-in constructor with that name.
2. Evaluate PropertyAssignment.
3. Call the [[DefineOwnProperty]] method of Result(1) with arguments Result(2).name, Result(2).descriptor, false.
4. Return Result(1).
The production

\textit{PropertyNameAndValueList} \rightarrow \textit{PropertyNameAndValueList}, \textit{PropertyAssignment}

is evaluated as follows:
1. Evaluate \textit{PropertyNameAndValueList}.
2. Evaluate \textit{PropertyAssignment}.
3. Call the \{\texttt{DefineOwnProperty}\} method of Result(1) with arguments (Result(2).name, Result(2).descriptor, false).
4. Return Result(1).

The production \textit{PropertyAssignment} \rightarrow \textit{PropertyName} \rightarrow \textit{AssignmentExpression} is evaluated as follows:
1. Evaluate \textit{PropertyName}.
2. Evaluate \textit{AssignmentExpression}.
3. Call GetValue(Result(2)).
4. Create Property Descriptor\{\{Value\}: Result(2), \{Writable\}: \text{true}, \{Enumerable\}: \text{true}, \{Configurable\}: \text{true}\}
5. Return Property Identifier (Result(1), Result(4)).

The production \textit{PropertyAssignment} \rightarrow \textit{get} \textit{PropertyName} \{ \textit{FunctionBody} \} is evaluated as follows:
1. Evaluate \textit{PropertyName}.
2. Create a new Function object as specified in 13.2 with an empty parameter list and body specified by \textit{FunctionBody}. Pass in the lexical environment of the current execution context as the \textit{Scope}.
3. Create Property Descriptor\{\{Getter\}: Result(2), \{Enumerable\}: \text{true}, \{Configurable\}: \text{true}\}
4. Return Property Identifier (Result(1), Result(3)).

The production \textit{PropertyAssignment} \rightarrow \textit{set} \textit{PropertyName} \{ \textit{PropertySetParameterList} \} \{ \textit{FunctionBody} \} is evaluated as follows:
1. Evaluate \textit{PropertyName}.
2. Create a new Function object as specified in 13.2 with parameter list specified by \textit{PropertySetParameterList} and body specified by \textit{FunctionBody}. Pass in the lexical environment of the current execution context as the \textit{Scope}.
3. Create Property Descriptor\{\{Setter\}: Result(2), \{Enumerable\}: \text{true}, \{Configurable\}: \text{true}\}
4. Return Property Identifier (Result(1), Result(3)).

The production \textit{PropertyName} \rightarrow \textit{IdentifierName} is evaluated as follows:
1. Form a string literal containing the same sequence of characters as the \textit{IdentifierName}.
2. Return Result(1).

The production \textit{PropertyName} \rightarrow \textit{StringLiteral} is evaluated as follows:
1. Return the value of the \textit{StringLiteral}.

The production \textit{PropertyName} \rightarrow \textit{NumericLiteral} is evaluated as follows:
1. Form the value of the \textit{NumericLiteral}.
2. Return ToString(Result(1)).

11.1.6 The Grouping Operator

The production \textit{PrimaryExpression} \rightarrow \{ \textit{Expression} \} is evaluated as follows:
1. Evaluate \textit{Expression}. This may be of type Reference.
2. Return Result(1).

\textit{NOTE}
This algorithm does not apply GetValue to Result(1). The principal motivation for this is so that operators such as \texttt{delete} and \texttt{typeof} may be applied to parenthesised expressions.

11.2 Left-Hand-Side Expressions

\textbf{Syntax}

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11.2.1 Property Accessors

Properties are accessed by name, using either the dot notation:

MemberExpression . IdentifierName
CallExpression . IdentifierName

or the bracket notation:

MemberExpression [ Expression ]
CallExpression [ Expression ]

The dot notation is explained by the following syntactic conversion:

MemberExpression . IdentifierName

is identical in its behaviour to

MemberExpression [ IdentifierName ]

and similarly

CallExpression . IdentifierName

is identical in its behaviour to

CallExpression [ IdentifierName ]

where IdentifierName is a string literal containing the same sequence of characters as the IdentifierName.

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, throw a TypeError exception.
4. If Result(2) does not implement the internal [[Construct]] method, throw a TypeError exception.
5. Call the [[Construct]] method on Result(2), providing no arguments (that is, an empty list of arguments).
6. Return Result(5).

The production MemberExpression : new MemberExpression Arguments is evaluated as follows:

1. Evaluate MemberExpression.
2. Call GetValue(Result(1)).
3. Evaluate Arguments, producing an internal list of argument values (11.2.4).
4. If Type(Result(2)) is not Object, throw a TypeError exception.
5. If Result(2) does not implement the internal [[Construct]] method, throw a TypeError exception.
6. Call the [[Construct]] method on Result(2), providing the list Result(3) as the argument values.
7. Return Result(6).

### 11.2.3 Function Calls

The production CallExpression : MemberExpression Arguments is evaluated as follows:

1. Evaluate MemberExpression.
2. Call GetValue(Result(1)).
3. Evaluate Arguments, producing an internal list of argument values (see 11.2.4).
4. If Type(Result(2)) is not Object, throw a TypeError exception.
5. If IsCallable(Result(2)) is false, throw a TypeError exception.
6. If Type(Result(1)) is Reference, and IsPropertyReference(Result(1)) is true, Result(6) is GetBase(Result(1)). Otherwise, Result(6) is null.
7. Call the [[Call]] method on Result(2), providing Result(6) as the this value and providing the list Result(3) as the argument values.
8. Return Result(7).

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(2) is a native ECMAScript object. Whether calling a host object can return a value of type Reference is implementation-dependent. If a value of type Reference is returned, it must be a non-strict Property Reference.

### 11.2.4 Argument Lists

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

The production Arguments : ( ) is evaluated as follows:

1. Return an empty internal list of values.

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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.

### 11.2.5 Function Expressions

The production `MemberExpression : FunctionExpression` is evaluated as follows:
1. Evaluate `FunctionExpression`.
2. Return Result(1).

### 11.3 Postfix Expressions

#### Syntax

PostfixExpression :
- `LeftHandSideExpression` `LeftHandSideExpression` `LeftHandSideExpression` `LeftHandSideExpression` (no LineTerminator here) `++`
- `LeftHandSideExpression` (no LineTerminator here) `--`

#### 11.3.1 Postfix Increment Operator

The production `PostfixExpression : LeftHandSideExpression` (no LineTerminator here) `++` is evaluated as follows:
1. Evaluate `LeftHandSideExpression`.
2. Call GetValue(Result(1)).
3. If Type(Result(2)) is Decimal, then
   a. Perform the addition method as defined in IEEE 754-2008 with arguments Result(2) and the decimal value 1m.
   b. Call PutValue(Result(1), Result(3a)).
   c. Return Result(1).
4. Call ToNumber(Result(2)).
5. Add the value 1 to Result(4), using the same rules as for the `+` operator (see 11.6.3).
6. Call PutValue(Result(1), Result(5)).
7. Return Result(5).

#### 11.3.2 Postfix Decrement Operator

The production `PostfixExpression : LeftHandSideExpression` (no LineTerminator here) `--` is evaluated as follows:
1. Evaluate `LeftHandSideExpression`.
2. Call GetValue(Result(1)).
3. If Type(Result(2)) is Decimal, then
   a. Perform the subtraction method as defined in IEEE 754-2008 with arguments Result(2) and the decimal value 1m.
   b. Call PutValue(Result(1), Result(3a)).
   c. Return Result(1).
4. Call ToNumber(Result(2)).
5. Subtract the value 1 from Result(3), using the same rules as for the - operator (11.6.3).
6. Call PutValue(Result(1), Result(2)).
7. 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. If Type(Result(1)) is not Reference, return true.
3. If UnresolvableReference(Result(1)) return true.
4. If IsPropertyReference(Result(1)) is true, then
   a. Call the [[Delete]] method on GetBase(Result(1)) providing GetReferencedName(Result(1))
      and IsStrictReference(Result(1)) as the arguments.
   b. Return Result(4a).
5. Else, Result(1) is an environment record reference, so
   a. If GetBase(Result(1)) is a declarative environment record, return false.
   b. Get the binding object of the object environment record that is the value of
      GetBase(Result(1)).
   c. Call the [[Delete]] method on Result(5b), providing GetReferencedName(Result(1)) and
      IsStrictReference(Result(1)) as the arguments.
   d. Return Result(5c).

11.4.1.1 Strict Mode Restrictions

When a delete operator occurs within an execution context that is subset restricted to the strict
subset, its UnaryExpression is further limited to being a MemberExpression. In addition, if the
property to be deleted has the attribute {
    Configurable: false
}, a TypeError exception is thrown.

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 not Reference, go to step 4.
3. If IsUnresolvableReference(Result(1)) is true, return "undefined".
4. Call GetValue(Result(1)).
5. Return a string determined by Type(Result(4)) according to the following table:
<table>
<thead>
<tr>
<th>Type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>&quot;undefined&quot;</td>
</tr>
<tr>
<td>Null</td>
<td>&quot;object&quot;</td>
</tr>
<tr>
<td>Boolean</td>
<td>&quot;boolean&quot;</td>
</tr>
<tr>
<td>Number</td>
<td>&quot;number&quot;</td>
</tr>
<tr>
<td>Decimal</td>
<td>&quot;decimal&quot;</td>
</tr>
<tr>
<td>String</td>
<td>&quot;string&quot;</td>
</tr>
<tr>
<td>Object (native and doesn’t implement [[Call]])</td>
<td>&quot;object&quot;</td>
</tr>
<tr>
<td>Object (native and implements [[Call]])</td>
<td>&quot;function&quot;</td>
</tr>
<tr>
<td>Object (host)</td>
<td>Implementation-dependent</td>
</tr>
</tbody>
</table>

### 11.4.4 Prefix Increment Operator

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

1. Evaluate `UnaryExpression`.
2. Call `GetValue(Result(1))`.
3. If `Type(Result(2))` is Decimal, then
   a. Perform the addition method as defined in IEEE 754-2008 with arguments `Result(2)` and the decimal value `1m`.
   b. Call `PutValue(Result(1), Result(3a))`.
   c. Return `Result(1)`.
4. Call `ToNumber(Result(2))`.
5. Add the value `1` to `Result(4)`, using the same rules as for the `+` operator (see 11.6.3).
6. Call `PutValue(Result(1), Result(5))`.
7. Return `Result(5)`.

### 11.4.5 Prefix Decrement Operator

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

1. Evaluate `UnaryExpression`.
2. Call `GetValue(Result(1))`.
3. If `Type(Result(2))` is Decimal, then
   a. Perform the subtraction method as defined in IEEE 754-2008 with arguments `Result(2)` and the decimal value `1m`.
   b. Call `PutValue(Result(1), Result(3a))`.
   c. Return `Result(3a)`.
4. Call `ToNumber(Result(2))`.
5. Subtract the value `1` from `Result(4)`, using the same rules as for the `-` operator (see 11.6.3).
6. Call `PutValue(Result(1), Result(5))`.
7. Return `Result(5)`.

### 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. If `Type(Result(2))` is Decimal, then
   a. Return `Result(2)`.
4. Call `ToNumber(Result(2))`.
5. Return `Result(4)`.
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. If `Type(Result(2))` is `Decimal`, then
   a. Perform the negate method as defined in IEEE 754-2008 with argument `Result(2)`.
   b. Return `Result(3a)`.
4. Call `ToNumber(Result(2))`.
5. If `Result(3)` is `NaN`, return `NaN`.
6. Negate `Result(4)`, that is, compute a number with the same magnitude but opposite sign.
7. Return `Result(5)`.

11.4.8 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. If `Type(Result(2))` is Decimal and `Type(Result(4))` is Decimal, then
   a. Perform the corresponding Decimal method (multiplication, division, remainder) with arguments `Result(2)` and `Result(4)`.
   b. Return `Result(5a)`.
6. Call `ToNumber(Result(2))`.
7. Call `ToNumber(Result(4))`.
8. Apply the specified operation (*, /, or %) to `Result(6)` and `Result(7)`. See the notes below (11.5.1, 11.5.2, 11.5.3).
9. Return `Result(8)`.
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.
- In the remaining cases, where neither an infinity nor 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 a finite value by an infinity results in zero. The sign is 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.
- 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, the operation overflows; the result is then an infinity of appropriate sign. If the magnitude is too small to represent, 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 % operator yields the remainder of its operands from an implied division; the left operand is the dividend and the right operand is the divisor.

**NOTE**

In C and C++, the remainder operator accepts only integral operands; 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 behaviour 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. If Type(Result(2)) is Decimal and Type(Result(4)) is Decimal, then
   a. Perform the addition method as defined in IEEE 754-2008 with arguments Result(2) and Result(4).
   b. Return Result(5a).
6. Call ToPrimitive(Result(2)).
7. Call ToPrimitive(Result(4)).
8. If Type(Result(2)) is String or Type(Result(7)) is String, then
   a. Call ToString(Result(6)).
   b. Call ToString(Result(7)).
   c. Concatenate Result(8a) followed by Result(8b).
   d. Return Result(8c).
9. Call ToNumber(Result(6)).
10. Call ToNumber(Result(7)).
11. Apply the addition operation to Result(9) and Result(10). See the note below (11.6.3).
12. Return Result(11).

NOTE
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 $\text{AdditiveExpression : AdditiveExpression - MultiplicativeExpression}$ is evaluated as follows:

1. Evaluate AdditiveExpression.
2. Call GetValue(Result(1)).
3. Evaluate MultiplicativeExpression.
4. Call GetValue(Result(3)).
5. If Type(Result(2)) is Decimal and Type(Result(4)) is Decimal, then
   a. Perform subtraction method as defined in IEEE 754-2008 with arguments Result(2) and Result(4).
   b. Return Result(5).
6. Call ToNumber(Result(2)).
7. Call ToNumber(Result(4)).
8. Apply the subtraction operation to Result(6) and Result(7). See the note below (11.6.3).
9. Return Result(8).

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

$\text{ShiftExpression : AdditiveExpression}$
$\text{ShiftExpression << AdditiveExpression}$
$\text{ShiftExpression >> AdditiveExpression}$
$\text{ShiftExpression >>> AdditiveExpression}$

11.7.1 The Left Shift Operator (<<)
Performs a bitwise left shift operation on the left operand by the amount specified by the right operand.

The production $\text{ShiftExpression : ShiftExpression << AdditiveExpression}$ 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 ToUint32(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 operand by the amount specified by the
right operand.
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 ToUint32(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 operand by the amount specified by the
right operand.
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 ToUint32(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
   RelationalExpression instanceof ShiftExpression
   RelationalExpression in ShiftExpression
RelationalExpressionNoIn:
  ShiftExpression
  RelationalExpressionNoIn < ShiftExpression
  RelationalExpressionNoIn > ShiftExpression
  RelationalExpressionNoIn <= ShiftExpression
  RelationalExpressionNoIn >= ShiftExpression
  RelationalExpressionNoIn instanceof ShiftExpression

NOTE
The 'NoIn' variants are needed to avoid confusing the \texttt{in} operator in a relational expression with the \texttt{in} operator in a \texttt{for} statement.

Semantics
The result of evaluating a relational operator is always of type Boolean, reflecting whether the relationship named by the operator holds between its two operands.

The RelationalExpressionNoIn productions are evaluated in the same manner as the RelationalExpression productions except that the contained RelationalExpressionNoIn is evaluated instead of the contained RelationalExpression.

11.8.1 The Less-than Operator ( < )
The production RelationalExpression : RelationalExpression < ShiftExpression is evaluated as follows:
\begin{enumerate}
  \item Evaluate RelationalExpression.
  \item Call GetValue(Result(1)).
  \item Evaluate ShiftExpression.
  \item Call GetValue(Result(3)).
  \item Perform the comparison Result(2) < Result(4). (see 11.8.5)
  \item If Result(6) is undefined, return false. Otherwise, return Result(6).
\end{enumerate}

11.8.2 The Greater-than Operator ( > )
The production RelationalExpression : RelationalExpression > ShiftExpression is evaluated as follows:
\begin{enumerate}
  \item Evaluate RelationalExpression.
  \item Call GetValue(Result(1)).
  \item Evaluate ShiftExpression.
  \item Call GetValue(Result(3)).
  \item Perform the comparison Result(4) < Result(2) with LeftFirst equal to false. (see 11.8.5).
  \item If Result(6) is undefined, return false. Otherwise, return Result(6).
\end{enumerate}

11.8.3 The Less-than-or-equal Operator ( <= )
The production RelationalExpression : RelationalExpression <= ShiftExpression is evaluated as follows:
\begin{enumerate}
  \item Evaluate RelationalExpression.
  \item Call GetValue(Result(1)).
  \item Evaluate ShiftExpression.
  \item Call GetValue(Result(3)).
  \item Perform the comparison Result(4) < Result(2) with LeftFirst equal to false. (see 11.8.5).
  \item If Result(6) is true or undefined, return false. Otherwise, return true.
\end{enumerate}

11.8.4 The Greater-than-or-equal Operator ( >= )
The production RelationalExpression : RelationalExpression >= ShiftExpression is evaluated as follows:
\begin{enumerate}
  \item Evaluate RelationalExpression.
  \item Call GetValue(Result(1)).
  \item Evaluate ShiftExpression.
  \item Call GetValue(Result(3)).
  \item Perform the comparison Result(2) < Result(4). (see 11.8.5).
  \item If Result(6) is true or undefined, return false. Otherwise, return true.
\end{enumerate}
### 11.8.5 The Abstract Relational Comparison Algorithm

The comparison \( x < y \), where \( x \) and \( y \) are values, produces `true`, `false`, or `undefined` (which indicates that at least one operand is NaN). In addition to \( x \) and \( y \) the algorithm takes a boolean flag named `LeftFirst` as a parameter. The flag is used to control the order in which operations with potentially visible side-effects are performed upon \( x \) and \( y \). It is necessary because ECMAScript specifies left to right evaluation of expressions. The default value of `LeftFirst` is `true` and indicates that the \( x \) parameter corresponds to an expression that occurs to the left of the \( y \) parameters corresponding expression. If `LeftFirst` is `false`, the reverse is the case and operations must be performed upon \( y \) before \( x \). Such a comparison is performed as follows:

1. If the `LeftFirst` flag is `true`, then
   a. Let \( px \) be the result of calling `ToPrimitive(x, hint Number)`.  
   b. Let \( py \) be the result of calling `ToPrimitive(y, hint Number)`.  
2. Else the order of evaluation needs to be reversed to preserve left to right evaluation
   a. Let \( py \) be the result of calling `ToPrimitive(y, hint Number)`.  
   b. Let \( px \) be the result of calling `ToPrimitive(x, hint Number)`.  
3. If `Type(px)` is `String` and `Type(py)` 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. Let \( nx \) be the result of calling `ToNumber(px)`. Because of \( px \) and \( py \) are primitive values evaluation order is not important.
5. Let \( ny \) be the result of calling `ToNumber(py)`.
6. If \( px \) is `NaN`, return `undefined`.  
7. If \( py \) is `NaN`, return `undefined`.  
8. If \( px \) and \( py \) are the same number value, return `false`.  
9. If \( px \) is +0 and \( py \) is −0, return `false`.  
10. If \( px \) is −0 and \( py \) is +0, return `false`.  
11. If \( px \) is +\( \infty \), return `false`.  
12. If \( px \) is −\( \infty \), return `true`.  
13. If \( py \) is −\( \infty \), return `false`.  
14. If \( px \) is −\( \infty \), return `true`.  
15. If the mathematical value of \( px \) is less than the mathematical value of \( py \)—note that these mathematical values are both finite and not both zero—return `true`. Otherwise, return `false`.  
16. If \( py \) is a prefix of \( px \), 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 \( px \) is a prefix of \( py \), return `true`.  
18. Let \( k \) be the smallest nonnegative integer such that the character at position \( k \) within \( px \) is different from the character at position \( k \) within \( py \). (There must be such a \( k \), for neither string is a prefix of the other.)
19. Let \( m \) be the integer that is the code point value for the character at position \( k \) within \( px \).  
20. Let \( n \) be the integer that is the code point value for the character at position \( k \) within \( py \).  
21. If `Type(m)` is `Decimal` or `Type(n)` is `Decimal`, then  
   a. Call `ToDecimal(m)`  
   b. Call `ToDecimal(n)`  
   c. Perform the compareQuietLess method as defined in IEEE 754-2008 with arguments `Result(2)` and `Result(2)`.  
   d. Return `Result(2)`.
22. If \( m < n \), return `true`. Otherwise, return `false`.  

**NOTE**

The comparison of strings uses a simple lexicographic ordering on sequences of code point values. There is no attempt to use the more complex, semantically oriented definitions of character or string equality and collating order defined in the Unicode specification. Therefore strings that are canonically equal according to the Unicode standard could test as unequal. In effect this algorithm assumes that both strings are already in normalised form.

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11.8.6 The instanceof operator
The production `RelationalExpression: RelationalExpression instanceof ShiftExpression` is evaluated as follows:
1. Evaluate `RelationalExpression`.
2. Call `GetValue(Result(1))`.
3. Evaluate `ShiftExpression`.
4. Call `GetValue(Result(3))`.
5. If `Result(4)` is not an object, throw a `TypeError` exception.
6. If `Result(4)` does not have a `[[HasInstance]]` method, throw a `TypeError` exception.
7. Call the `[[HasInstance]]` method of `Result(4)` with parameter `Result(2)`.
8. Return `Result(7)`.

11.8.7 The in operator
The production `RelationalExpression : RelationalExpression in ShiftExpression` is evaluated as follows:
1. Evaluate `RelationalExpression`.
2. Call `GetValue(Result(1))`.
3. Evaluate `ShiftExpression`.
4. Call `GetValue(Result(3))`.
5. If `Result(4)` is not an object, throw a `TypeError` exception.
6. Call `ToString(Result(2))`.
7. Call the `[[HasProperty]]` method of `Result(4)` with parameter `Result(6)`.
8. Return `Result(7)`.

11.9 Equality Operators

Syntax
```plaintext
EqualityExpression :
    RelationalExpression
    EqualityExpression == RelationalExpression
    EqualityExpression !== RelationalExpression
    EqualityExpression === RelationalExpression
    EqualityExpression !== RelationalExpression

EqualityExpressionNoIn :
    RelationalExpressionNoIn
    EqualityExpressionNoIn == RelationalExpressionNoIn
    EqualityExpressionNoIn !== RelationalExpressionNoIn
    EqualityExpressionNoIn === RelationalExpressionNoIn
    EqualityExpressionNoIn !== RelationalExpressionNoIn
```

Semantics
The result of evaluating an equality operator is always of type Boolean, reflecting whether the relationship named by the operator holds between its two operands.

The `EqualityExpressionNoIn` productions are evaluated in the same manner as the `EqualityExpression` productions except that the contained `EqualityExpressionNoIn` and `RelationalExpressionNoIn` are evaluated instead of the contained `EqualityExpression` and `RelationalExpression`, respectively.

11.9.1 The Equals Operator ( == )
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 11.9.3).
6. Return Result(5).

11.9.2 The Does-not-equals Operator ( != )
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 11.9.3).
6. If `Result(5)` is `true`, return `false`. Otherwise, return `true`.

11.9.3 The Abstract Equality Comparison Algorithm
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(x)`, go to step 15.
2. If `Type(x)` is Undefined, return `true`.
3. If `Type(x)` is Null, return `true`.
4. If `Type(x)` is Decimal, then
   a. Perform the compareQuietEqual method as defined in IEEE 754-2008 with arguments `x` and `y`.
   b. Return Result(4a).
5. If `Type(x)` is not Number, go to step 12.
6. If `x` is NaN, return false.
7. If `y` is NaN, return false.
8. If `x` is the same number value as `y`, return true.
9. If `x` is +0 and `y` is −0, return true.
10. If `x` is −0 and `y` is +0, return true.
11. Return false.
12. 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`.
13. If `Type(x)` is Boolean, return `true` if `x` and `y` are both `true` or both `false`. Otherwise, return `false`.
14. Return `true` if `x` and `y` refer to the same object. Otherwise, return `false`.
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 `ToNumber(y)`.
17. If `Type(x)` is String and `Type(y)` is Number, return the result of the comparison `ToNumber(x)`.
18. If `Type(x)` is Decimal or `Type(y)` is Decimal then
   a. Call ToDecimal(`x`).
   b. Call ToDecimal(`y`).
   c. Perform the compareQuietEqual method as defined in IEEE 754-2008 with arguments Result(19a) and Result(19b).
   d. Return Result(19c).
19. If `Type(x)` is Boolean, return the result of the comparison `ToNumber(x) == y`.
20. If `Type(y)` is Boolean, return the result of the comparison `ToNumber(y) == x`.
21. If `Type(x)` is either String or Number and `Type(y)` is Object, return the result of the comparison `ToPrimitive(x) == y`.
22. If `Type(x)` is Object and `Type(y)` is either String or Number, return the result of the comparison `ToPrimitive(x) == y`.
23. Return `false`.

**NOTE**
Given the above definition of equality:

* String comparison can be forced by: `"" + a == "" + b`.
* Numeric comparison can be forced by: `a - 0 == b - 0`.

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Boolean comparison can be forced by: \(!a == !b\).

The equality operators maintain the following invariants:
\(A \neq B\) is equivalent to \(! (A == B)\).
\(A == B\) is equivalent to \(B == A\), except in the order of evaluation of \(A\) and \(B\).

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.

Comparison of strings uses a simple equality test on sequences of code point values. There is no attempt to use the more complex, semantically oriented definitions of character or string equality and collating order defined in the Unicode 2.0 specification. Therefore strings that are canonically equal according to the Unicode standard could test as unequal. In effect this algorithm assumes that both strings are already in normalised form.

11.9.4 The Strict Equals Operator ( \(===\))

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 \(Result(5)\).

11.9.5 The Strict Does-not-equal Operator ( \(!==\))

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 \(true\).

11.9.6 The Strict Equality Comparison Algorithm

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 \(Type(y)\), return \(false\).
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. If \(Type(x)\) is \(Decimal\), then
   a. Call \(ToDecimal(x)\).
   b. Call \(ToDecimal(y)\).
   c. Perform the compareQuietEqual method as defined in IEEE 754-2008 with arguments \(Result(13a)\) and \(Result(13b)\).
Return Result(13c).

14. Return true if x and y refer to the same object. Otherwise, return false.

### 11.10 Binary Bitwise Operators

**Syntax**

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

- **BitwiseANDExpressionNoIn**:
  - EqualityExpressionNoIn
  - BitwiseANDExpressionNoIn & EqualityExpressionNoIn

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

- **BitwiseXORExpressionNoIn**:
  - BitwiseANDExpressionNoIn
  - BitwiseXORExpressionNoIn ^ BitwiseANDExpressionNoIn

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

- **BitwiseORExpressionNoIn**:
  - BitwiseXORExpressionNoIn
  - BitwiseORExpressionNoIn | BitwiseXORExpressionNoIn

**Semantics**

The production $A @ B$, 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

- **LogicalANDExpressionNoIn**:
  - BitwiseORExpressionNoIn
  - LogicalANDExpressionNoIn && BitwiseORExpressionNoIn

- **LogicalORExpression**:
  - LogicalANDExpression
  - LogicalORExpression || LogicalANDExpression
LogicalORExpressionNoIn : 
LogicalANDExpressionNoIn 
LogicalORExpressionNoIn | | LogicalANDExpressionNoIn

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).

The LogicalANDExpressionNoIn and LogicalORExpressionNoIn productions are evaluated in the same manner as the LogicalANDExpression and LogicalORExpression productions except that the contained LogicalANDExpressionNoIn, BitwiseORExpressionNoIn and LogicalORExpressionNoIn are evaluated instead of the contained LogicalANDExpression, BitwiseORExpression and LogicalORExpression, respectively.

NOTE

The value produced by & & or | | operator is not necessarily of type Boolean. The value produced will always be the value of one of the two operand expressions.

11.12 Conditional Operator ( ? : )

Syntax

ConditionalExpression : 
LogicalORExpression 
AssignmentExpression : AssignmentExpression

ConditionalExpressionNoIn : 
LogicalORExpressionNoIn 
AssignmentExpressionNoIn : 
AssignmentExpressionNoIn 
AssignmentExpression : AssignmentExpressionNoIn

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).

The ConditionalExpressionNoIn production is evaluated in the same manner as the ConditionalExpression production except that the contained LogicalORExpressionNoIn, AssignmentExpression and AssignmentExpressionNoIn are evaluated instead of the contained LogicalORExpression, first AssignmentExpression and second AssignmentExpression, respectively.

**NOTE**
The grammar for a ConditionalExpression in ECMAScript is a little bit different from that in C and Java, which each allow the second subexpression to be an Expression but restrict the third expression to be a ConditionalExpression. The motivation for this difference in ECMAScript is to allow an assignment expression to be governed by either arm of a conditional and to eliminate the confusing and fairly useless case of a comma expression as the centre expression.

### 11.13 Assignment Operators

#### Syntax

**AssignmentExpression**: ConditionalExpression

**AssignmentExpressionNoIn**: ConditionalExpressionNoIn

**AssignmentOperator**: one of

- `=`
- `+=`
- `-=`
- `*=`
- `/=`
- `>>=`
- `>>>=`
- `&=`
- `^=`
- `|=`

#### Semantics

The AssignmentExpressionNoIn productions are evaluated in the same manner as the AssignmentExpression productions except that the contained ConditionalExpressionNoIn and AssignmentExpressionNoIn are evaluated instead of the contained ConditionalExpression and AssignmentExpression, respectively.

#### 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).

#### 11.13.1.1 Strict Mode Restrictions

When a simple assignment occurs within an execution context that is subset restricted to the strict subset, its `LeftHandSide` must not evaluate to an unresolvable reference. If it does a `ReferenceError` exception is thrown. The `LeftHandSide` also may not be a reference to a property with the attribute value `[[Writable]]:false` nor to a non-existent property of an object whose `[[Extensible]]` property has the value `false`. In these cases a `TypeError` exception is thrown.

#### 11.13.2 Compound Assignment (`op=`)

The production `AssignmentExpression : LeftHandSideExpression op = AssignmentExpression`, where `op` represents one of the 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 `op` to Result(2) and Result(4).
6. Call PutValue(Result(1), Result(5)).
7. Return Result(5).

11.13.2.1 Strict Mode Restrictions
The same restrictions apply as specified in 11.13.1.1.

11.14 Comma Operator ( , )
Syntax
Expression :
AssignmentExpression
Expression , AssignmentExpression
ExpressionNoIn :
AssignmentExpressionNoIn
ExpressionNoIn , AssignmentExpressionNoIn

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).

The ExpressionNoIn production is evaluated in the same manner as the Expression production except that the contained ExpressionNoIn and AssignmentExpressionNoIn are evaluated instead of the contained Expression and AssignmentExpression, respectively.
12 Statements

Syntax

Statement :
   SubStatement
   VariableStatement
   FunctionDeclaration

SubStatement :
   Block
   EmptyStatement
   ExpressionStatement
   IfStatement
  IterationStatement
   ContinueStatement
   BreakStatement
   ReturnStatement
   WithStatement
   LabelledStatement
   SwitchStatement
   ThrowStatement
   TryStatement
   DebuggerStatement

Semantics

A Statement can be part of a LabelledStatement, which itself can be part of a LabelledStatement, and so on. The labels introduced this way are collectively referred to as the “current label set” when describing the semantics of individual statements. A LabelledStatement has no semantic meaning other than the introduction of a label to a label set. The label set of an IterationStatement or a SwitchStatement initially contains the single element empty. The label set of any other statement is initially empty.

Note:
TBD: Implementations have been known to support FunctionDeclaration in a SubStatement; however there is no uniform support. It is impossible to reconcile their differing semantics, and hence this specification excludes their possibility.

12.1 Block

Syntax

Block :
   { StatementList_opt }

StatementList :
   Statement
   StatementList
   StatementList

Semantics

The production Block : { } is evaluated as follows:

1. Return (normal, empty, empty).

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

1. Establish a new lexical block execution context using any contextually supplied block parameters,
2. Evaluate StatementList using the new execution context,
3. Exit the execution context established in step 1, restoring the previous execution context.
4. Return Result(0).

The production StatementList : Statement is evaluated as follows:

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1. Evaluate \textit{Statement}.
2. If an exception was thrown, return \((\text{throw}, V, \text{empty})\) where \(V\) is the exception. (Execution now proceeds as if no exception were thrown.)
3. Return \text{Result}(1).

The production \textit{StatementList} : \textit{StatementList} \textit{Statement} is evaluated as follows:
1. Evaluate \textit{StatementList}.
2. If \text{Result}(1) is an abrupt completion, return \text{Result}(1).
3. Evaluate \textit{Statement}.
4. If an exception was thrown, return \((\text{throw}, V, \text{empty})\) where \(V\) is the exception. (Execution now proceeds as if no exception were thrown.)
5. If \text{Result}(3).\text{value} is \text{empty}, let \(V = \text{Result}(1).\text{value}\), otherwise let \(V = \text{Result}(3).\text{value}\).
6. Return \((\text{Result}(3).\text{type}, V, \text{Result}(3).\text{target})\).

12.11 \textbf{Strict Mode Restrictions}

A \textit{VariableStatement} within an execution context that is subset restricted to the \textit{strict} subset, may not occur as the \textit{StatementList} of a \textit{Block}. The occurrence of a \textit{VariableStatement} in such a context must be treated as a syntax error.

12.2 \textbf{Variable statement}

\textbf{Syntax}

\textit{VariableStatement} :
\begin{verbatim}
    var VariableDeclarationList ;
\end{verbatim}
\textit{VariableDeclarationList} :
\begin{verbatim}
    VariableDeclaration
    VariableDeclarationList , VariableDeclaration
\end{verbatim}
\textit{VariableDeclarationListNoIn} :
\begin{verbatim}
    VariableDeclarationNoIn
    VariableDeclarationListNoIn , VariableDeclarationNoIn
\end{verbatim}
\textit{VariableDeclaration} :
\begin{verbatim}
    Identifier Initialiser opt
\end{verbatim}
\textit{VariableDeclarationNoIn} :
\begin{verbatim}
    Identifier InitialiserNoIn opt
    Initialiser = AssignmentExpression
    InitialiserNoIn = AssignmentExpressionNoIn
\end{verbatim}

\textbf{Description}

A \textit{variable statement} declares variables that are created as defined in section 10.3.1. Variables are initialised to \textit{undefined} when created. A variable with an \textit{Initialiser} is assigned the value of its \textit{AssignmentExpression} when the \textit{VariableStatement} is executed, not when the variable is created.

\textbf{Semantics}

The production \textit{VariableStatement} : \textit{var} \textit{VariableDeclarationList} ; is evaluated as follows:
1. Evaluate \textit{VariableDeclarationList}.
2. Return \((\text{normal, empty, empty})\).

The production \textit{VariableDeclarationList} : \textit{VariableDeclaration} is evaluated as follows:
1. Evaluate \textit{VariableDeclaration}.

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

1. Evaluate `VariableDeclarationList`.
2. Evaluate `VariableDeclaration`.

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

1. **Return** a string value containing the same sequence of characters as in the `Identifier`.
2. Evaluate `Initialiser`.
3. Call `GetValue(Result(2))`.
4. Call the `SetMutableBinding(N,Y,S)` concrete method of the execution context’s `VariableEnvironment` passing the `Identifier`, `Result(3)`, and `strict` as arguments.
5. Return a string value containing the same sequence of characters as in the `Identifier`.

The production `Initialiser` : `=` `AssignmentExpression` is evaluated as follows:

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

The `VariableDeclarationListNoIn`, `VariableDeclarationNoIn` and `InitialiserNoIn` productions are evaluated in the same manner as the `VariableDeclarationList`, `VariableDeclaration` and `Initialiser` productions except that the contained `VariableDeclarationListNoIn`, `VariableDeclarationNoIn`, `InitialiserNoIn` and `AssignmentExpressionNoIn` are evaluated instead of the contained `VariableDeclarationList`, `VariableDeclaration`, `Initialiser` and `AssignmentExpression`, respectively.

### 12.3 Empty Statement

**Syntax**

```
EmptyStatement : ;
```

**Semantics**

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

1. Return `(normal, empty, empty)`.

### 12.4 Expression Statement

**Syntax**

```
ExpressionStatement : [lookahead ! {, function}] Expression ;
```

Note that an `ExpressionStatement` cannot start with an opening curly brace because that might make it ambiguous with a `Block`. Also, an `ExpressionStatement` cannot start with the `function` keyword because that might make it ambiguous with a `FunctionDeclaration`.

**Semantics**

The production `ExpressionStatement` : `[lookahead ! {, function}] Expression ;` is evaluated as follows:

1. Evaluate `Expression`.
2. Call `GetValue(Result(1))`.
3. Return `(normal, Result(2), empty)`.

### 12.5 The if Statement

**Syntax**

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IfStatement:
    if (Expression) SubStatement else SubStatement
    if (Expression) SubStatement

Each else for which the choice of associated if is ambiguous shall be associated with the nearest possible if that would otherwise have no corresponding else.

Semantics
The production IfStatement : if (Expression) SubStatement else SubStatement 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 SubStatement.
6. Return Result(5).
7. Evaluate the second SubStatement.
8. Return Result(7).

The production IfStatement : if (Expression) SubStatement 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, empty, empty).
5. Evaluate SubStatement.
6. Return Result(5).

12.6 Iteration Statements
An iteration statement consists of a header (which consists of a keyword and a parenthesised control construct) and a body (which consists of a Statement).

Syntax
IterationStatement :
    do SubStatement while (Expression );
    while (Expression) SubStatement
for (ExpressionNoIn; Expressionopt ; Expressionopt) SubStatement
for (LeftHandSideExpression in Expressionopt) SubStatement
for (var VariableDeclarationNoIn in Expressionopt) SubStatement

12.6.1 The do-while Statement
The production do SubStatement while (Expression ); is evaluated as follows:
1. Let V = empty.
2. Evaluate SubStatement.
3. If Result(2).value is not empty, let V = Result(2).value.
4. If Result(2).type is continue and Result(2).target is in the current label set, go to step 7.
5. If Result(2).type is break and Result(2).target is in the current label set, return (normal, V, empty).
6. If Result(2) is an abrupt completion, return Result(2).
7. Evaluate Expression.
8. Call GetValue(Result(7)).
9. Call ToBoolean(Result(8)).
10. If Result(9) is true, go to step 2.
11. Return (normal, V, empty);

12.6.2 The while statement
The production IterationStatement : while (Expression) SubStatement is evaluated as follows:
1. Let $V = \text{empty}$.
2. Evaluate $Expression$.
3. Call $GetVal(\text{Result}(2))$.
4. Call $\text{ToBoolean}(\text{Result}(3))$.
5. If $\text{Result}(4)$ is false, return $(\text{normal}, V, \text{empty})$.
7. If $\text{Result}(6).value$ is not empty, let $V = \text{Result}(6).value$.
8. If $\text{Result}(6).type$ is continue and $\text{Result}(6).target$ is in the current label set, return $(\text{normal}, \text{empty})$.
9. Go to step 2.

12.6.3 The for Statement

The production $\text{IterationStatement} : \text{for} \{ ExpressionNoInopt ; Expressionopt ; Expressionopt \} \text{SubStatement}$ is evaluated as follows:

1. If $ExpressionNoIn$ is not present, go to step 4.
2. Evaluate $ExpressionNoIn$.
3. Call $GetVal(\text{Result}(2))$. (This value is not used.)
4. Let $V = \text{empty}$.
5. If the first $Expression$ is not present, go to step 10.
6. Evaluate the first $Expression$.
7. Call $GetVal(\text{Result}(6))$.
8. Call $\text{ToBoolean}(\text{Result}(7))$.
9. If $\text{Result}(8)$ is false, go to step 19.
10. Evaluate $SubStatement$.
11. If $\text{Result}(10).value$ is not empty, let $V = \text{Result}(10).value$.
12. If $\text{Result}(10).type$ is continue and $\text{Result}(10).target$ is in the current label set, return $(\text{normal}, \text{empty})$.
14. If the second $Expression$ is not present, go to step 5.
15. Evaluate the second $Expression$.
16. Call $GetVal(\text{Result}(16))$. (This value is not used.)
17. Go to step 5.
18. Return $(\text{normal}, V, \text{empty})$.

The production $\text{IterationStatement} : \text{for} \{ \text{var} \ VariableDeclarationListNoIn ; Expressionopt ; Expressionopt \} \text{SubStatement}$ is evaluated as follows:

1. Evaluate $VariableDeclarationListNoIn$.
2. Let $V = \text{empty}$.
3. If the first $Expression$ is not present, go to step 8.
4. Evaluate the first $Expression$.
5. Call $GetVal(\text{Result}(4))$.
6. Call $\text{ToBoolean}(\text{Result}(5))$.
7. If $\text{Result}(6)$ is false, go to step 17.
8. Evaluate $SubStatement$.
9. If $\text{Result}(8).value$ is not empty, let $V = \text{Result}(8).value$.
10. If $\text{Result}(8).type$ is continue and $\text{Result}(8).target$ is in the current label set, return $(\text{normal}, \text{empty})$.
11. If $\text{Result}(8).type$ is break and $\text{Result}(8).target$ is in the current label set, return $(\text{normal}, \text{empty})$.
12. Go to step 3.
13. If the second $Expression$ is not present, go to step 3.
14. Evaluate the second $Expression$.
15. Call $GetVal(\text{Result}(14))$. (This value is not used.)
16. Go to step 3.
17. Return $(\text{normal}, V, \text{empty})$.  

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12.6.4 The for-in Statement

The production IterationStatement : for ( LeftHandSideExpression in Expression ) SubStatement is evaluated as follows:

1. Evaluate the Expression.
2. Call GetValue(Result(1)).
3. If Result(2) is null or undefined, return (normal, V, empty).
4. Call ToObject(Result(2)).
5. Let V = empty.
6. Get the name of the next property of Result(4) whose [[Enumerable]] attribute is true. If there is no such property, go to step 15.
7. Evaluate the LeftHandSideExpression (it may be evaluated repeatedly).
8. Call PutValue(Result(6), Result(2)).
10. If Result(9).value is not empty, let V = Result(9).value.
11. If Result(9).type is break and Result(9).target is in the current label set, go to step 15.
12. If Result(9).type is continue and Result(9).target is in the current label set, go to step 14.
13. If Result(9) is an abrupt completion, return Result(9).
15. Return (normal, V, empty).

The production IterationStatement : for ( var VariableDeclarationNoIn in Expression ) SubStatement is evaluated as follows:

1. Evaluate VariableDeclarationNoIn.
2. Evaluate Expression.
3. Call GetValue(Result(2)).
4. If Result(3) is null or undefined, return (normal, V, empty).
5. Call ToObject(Result(3)).
7. Get the name of the next property of Result(5) whose [[Enumerable]] attribute is true. If there is no such property, go to step 16.
8. Evaluate Result(1) as if it were an Identifier; see step 7 from the previous algorithm (it may be evaluated repeatedly).
9. Call PutValue(Result(7), Result(2)).
10. Evaluate SubStatement.
11. If Result(10).value is not empty, let V = Result(10).value.
12. If Result(10).type is break and Result(10).target is in the current label set, go to step 16.
13. If Result(10).type is continue and Result(10).target is in the current label set, go to step 14.
14. If Result(10) is an abrupt completion, return Result(10).
15. Go to step 8.

The mechanics of enumerating the properties (step 5 in the first algorithm, step 6 in the second) is not specified. 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 guaranteed not 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.

12.6.4.1 Strict Mode Restrictions

The same restrictions apply as specified in section 11.13.1.1.

12.7 The continue Statement

Syntax

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ContinueStatement:
  continue [no LineTerminator here] Identifier_opt;

Semantics
A program is considered syntactically incorrect if either of the following are true:

The program contains a `continue` statement without the optional `Identifier`, which is not nested, directly or indirectly (but not crossing function boundaries), within an `IterationStatement`.

The program contains a `continue` statement with the optional `Identifier`, where `Identifier` does not appear in the label set of an enclosing (but not crossing function boundaries) `IterationStatement`.

A `ContinueStatement` without an `Identifier` is evaluated as follows:
1. Return `(continue, empty, empty)`.

A `ContinueStatement` with the optional `Identifier` is evaluated as follows:
1. Return `(continue, empty, Identifier)`.

12.8 The break Statement

Syntax

BreakStatement:
  break [no LineTerminator here] Identifier_opt;

Semantics
A program is considered syntactically incorrect if either of the following are true:

The program contains a `break` statement without the optional `Identifier`, which is not nested, directly or indirectly (but not crossing function boundaries), within an `IterationStatement` or a `SwitchStatement`.

The program contains a `break` statement with the optional `Identifier`, where `Identifier` does not appear in the label set of an enclosing (but not crossing function boundaries) `Statement`.

A `BreakStatement` without an `Identifier` is evaluated as follows:
1. Return `(break, empty, empty)`.

A `BreakStatement` with an `Identifier` is evaluated as follows:
1. Return `(break, empty, Identifier)`.

12.9 The return Statement

Syntax

ReturnStatement:
  return [no LineTerminator here] Expression_opt;

Semantics
An ECMAScript program is considered syntactically incorrect if it contains a `return` statement that is not within a `FunctionBody`. A `return` statement causes a function to cease execution and return a value to the caller. If `Expression` is omitted, the return value is `undefined`. Otherwise, the return value is the value of `Expression`.

The production `ReturnStatement : return [no LineTerminator here] Expression_opt ;` is evaluated as:
1. If the `Expression` is not present, return `(return, undefined, empty)`.
2. Evaluate `Expression`.
3. Call GetValue(Result(2)).
4. Return `(return, Result(3), empty)`.

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12.10 The with Statement

Syntax

\[
\text{WithStatement} : \quad \text{with} \ (\ \text{Expression} \ ) \ \text{SubStatement}
\]

Description

The \textit{with} statement adds a computed object \textit{environment record} to the \textit{lexical environment} of the current execution context, then executes a statement with this augmented scope chain, then restores the \textit{lexical environment}.

Semantics

The production \textit{WithStatement} : \textit{with} \ (\ \textit{Expression} \ ) \ \textit{SubStatement} is evaluated as follows:

1. Evaluate \textit{Expression}.
2. Call GetValue(Result(1)).
3. Call ToObject(Result(2)).
4. Call NewObjectEnvironmentRecord(O,E) passing Result(3) and the current execution context’s LexicalEnvironment as the argument.
5. Set the LexicalEnvironment to Result(4).
7. Let \textit{C} be Result(6). If an exception was thrown in step 6, let \textit{C} be (\textit{throw}, \textit{V}, \textit{empty}), where \textit{V} is the exception. (Execution now proceeds as if no exception were thrown.)
8. Call PopEnvironmentRecord.
9. Return \textit{C}.

\textbf{NOTE}

No matter how control leaves the embedded ‘SubStatement’, whether normally or by some form of abrupt completion or exception, the \textit{LexicalEnvironment} is always restored to its former state.

12.10.1 Strict Mode Restrictions

An execution context that is subset restricted to the \textit{strict} subset, may not execute a \textit{WithStatement}. The occurrence of a \textit{WithStatement} in such a context must be treated as a syntax error.

12.11 The switch Statement

Syntax

\[
\text{SwitchStatement} : \quad \text{switch} \ (\ \text{Expression} \ ) \ \text{CaseBlock}
\]

\[
\text{CaseBlock} : \quad \{ \ \text{CaseClauses}_{opt} \} \quad \{ \ \text{CaseClauses}_{opt} \ \text{DefaultClause} \ \text{CaseClauses}_{opt} \}
\]

\[
\text{CaseClauses} : \quad \text{CaseClause} \quad \text{CaseClauses} \ \text{CaseClause}
\]

\[
\text{CaseClause} : \quad \text{case} \ \text{Expression} \ : \ \text{StatementList}_{opt}
\]

\[
\text{DefaultClause} : \quad \text{default} \ : \ \text{StatementList}_{opt}
\]

Semantics

The production \textit{SwitchStatement} : \textit{switch} \ (\ \textit{Expression} \ ) \ \textit{CaseBlock} is evaluated as follows:

1. Evaluate \textit{Expression}.
2. Call GetValue(Result(1)).

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3. Evaluate CaseBlock, passing it Result(2) as a parameter.
4. If Result(3).type is break and Result(3).target is in the current label set, return (normal, Result(3).value, empty).
5. Return Result(3).

The production CaseBlock : { CaseClausesopt } is given an input parameter, input, and is evaluated as follows:

1. Let V = empty.
2. Let A be the list of CaseClause items in source text order.
3. Let C be the next CaseClause in A. If there is no such CaseClause, then go to step 16.
4. Evaluate C.
5. If input is not equal to Result(4) as defined by the !== operator, then go to step 3.
6. If C does not have a StatementList, then go to step 10.
7. Evaluate C’s StatementList and let R be the result.
8. If R is an abrupt completion, then return R.
10. Let C be the next CaseClause in A. If there is no such CaseClause, then go to step 16.
11. If C does not have a StatementList, then go to step 10.
12. Evaluate C’s StatementList and let R be the result.
13. If R.value is not empty, then let V = R.value.
14. If R is an abrupt completion, then return (R.type, V, R.target).
15. Go to step 10.

The production CaseBlock : { CaseClausesopt, DefaultClause CaseClausesopt } is given an input parameter, input, and is evaluated as follows:

1. Let V = empty.
2. Let A be the list of CaseClause items in the first CaseClauses, in source text order.
3. Let C be the next CaseClause in A. If there is no such CaseClause, then go to step 11.
4. Evaluate C.
5. If input is not equal to Result(4) as defined by the !== operator, then go to step 3.
6. If C does not have a StatementList, then go to step 20.
7. Evaluate C’s StatementList and let R be the result.
8. If R is an abrupt completion, then return R.
11. Let B be the list of CaseClause items in the second CaseClauses, in source text order.
12. Let C be the next CaseClause in B. If there is no such CaseClause, then go to step 26.
13. Evaluate C.
14. If input is not equal to Result(13) as defined by the !== operator, then go to step 12.
15. If C does not have a StatementList, then go to step 31.
16. Evaluate C’s StatementList and let R be the result.
17. If R is an abrupt completion, then return R.
20. Let C be the next CaseClause in A. If there is no such CaseClause, then go to step 26.
21. If C does not have a StatementList, then go to step 20.
22. Evaluate C’s StatementList and let R be the result.
23. If R.value is not empty, then let V = R.value.
24. If R is an abrupt completion, then return (R.type, V, R.target).
26. If the DefaultClause does not have a StatementList, then go to step 30.
27. Evaluate the DefaultClause’s StatementList and let R be the result.
28. If R.value is not empty, then let V = R.value.
29. If R is an abrupt completion, then return (R.type, V, R.target).
30. Let B be the list of CaseClause items in the second CaseClauses, in source text order.
31. Let C be the next CaseClause in B. If there is no such CaseClause, then go to step 37.
32. If C does not have a StatementList, then go to step 31.
33. Evaluate C’s StatementList and let R be the result.
34. If \( V \) is not empty, then let \( V = V \) value.
35. If \( V \) is an abrupt completion, then return \( (R.type, V, R.target) \).
36. Go to step 31.
37. Return \( (normal, V, empty) \).

The production \text{CaseClause} : \text{case Expression} : \text{StatementList}_{opt} \text{ is evaluated as follows:}

1. Evaluate Expression.
2. Call GetValue(Result(1)).
3. Return Result(2).

\text{NOTE}

Evaluating CaseClause does not execute the associated StatementList. It simply evaluates the Expression and returns the value, which the CaseBlock algorithm uses to determine which StatementList to start executing.

12.12 \textbf{Labelled Statements}

\textbf{Syntax}

\text{LabelledStatement} :
\begin{align*}
\text{Identifier} : \text{Statement}
\end{align*}

\textbf{Semantics}

A \text{Statement} may be prefixed by a label. Labelled statements are only used in conjunction with labelled \text{break} and \text{continue} statements. ECMAScript has no \text{goto} statement.

An ECMAScript program is considered syntactically incorrect if it contains a \text{LabelledStatement} that is enclosed by a \text{LabelledStatement} with the same \text{Identifier} as label. This does not apply to labels appearing within the body of a \text{FunctionDeclaration} that is nested, directly or indirectly, within a labelled statement.

The production \text{Identifier} : \text{Statement} is evaluated by adding \text{Identifier} to the label set of \text{Statement} and then evaluating \text{Statement}. If the \text{LabelledStatement} itself has a non-empty label set, these labels are also added to the label set of \text{Statement} before evaluating it. If the result of evaluating \text{Statement} is \( (break, V, L) \) where \( L \) is equal to \text{Identifier}, the production results in \( (normal, V, empty) \).

Prior to the evaluation of a \text{LabelledStatement}, the contained \text{Statement} is regarded as possessing an empty label set, except if it is an \text{IterationStatement} or a \text{SwitchStatement}, in which case it is regarded as possessing a label-set consisting of the single element, \text{empty}.

12.13 \textbf{The throw statement}

\textbf{Syntax}

\text{ThrowStatement} :
\begin{align*}
\text{throw} [\text{noLineTerminator here}] \text{Expression} ;
\end{align*}

\textbf{Semantics}

The production \text{ThrowStatement} : \text{throw} [\text{noLineTerminator here}] \text{Expression} ; \text{is evaluated as:}

1. Evaluate Expression.
2. Call GetValue(Result(1)).
3. Return \( (throw, Result(2), empty) \).

12.14 \textbf{The try statement}

\textbf{Syntax}

\text{TryStatement} :
\begin{itemize}
  \item \text{try} Block Catch
  \item \text{try} Block Finally
  \item \text{try} Block Catch Finally
\end{itemize}
Catch:
  catch (Identifier) Block

Finally:
  finally Block

Description
The try statement encloses a block of code in which an exceptional condition can occur, such as a runtime error or a throw statement. The catch clause provides the exception-handling code. When a catch clause catches an exception, its Identifier is bound to that exception.

Semantics
The production TryStatement : try Block Catch is evaluated as follows:
1. Evaluate Block.
2. If Result(1).type is not throw, return Result(1).
3. Evaluate Catch with parameter Result(1).
4. Return Result(3).

The production TryStatement : try Block Finally is evaluated as follows:
1. Evaluate Block.
2. Evaluate Finally.
3. If Result(2).type is normal, return Result(1).
4. Return Result(2).

The production TryStatement : try Block Catch Finally is evaluated as follows:
1. Evaluate Block.
2. Let C = Result(1).
3. If Result(1).type is not throw, go to step 6.
4. Evaluate Catch with parameter Result(1).
5. Let C = Result(4).
6. Evaluate Finally.
7. If Result(6).type is normal, return C.
8. Return Result(6).

The production Catch : catch (Identifier) Block is evaluated as follows:
1. Let C be the parameter that has been passed to this production.
2. Call NewDeclarativeEnvironmentRecord(E) passing the current execution context’s LexicalEnvironment as the argument.
3. Call the CreateMutableBinding(N) concrete method of Result(2) passing the Identifier as the argument.
4. Call the SetMutableBinding(N,V,S) concrete method of Result(2) passing the Identifier, C.value, and false as arguments. Note that the last argument is immaterial in this situation.
5. Set the LexicalEnvironment to Result(2).
6. Evaluate Block.
7. Call PopEnvironmentRecord.
8. Return Result(6).

The production Finally : finally Block is evaluated as follows:
1. Evaluate Block.
2. Return Result(1).

12.15 Debugger statement
Syntax
DebuggerStatement :
  debugger ;
Semantics
Evaluating the DebuggerStatement production may allow an implementation to cause a breakpoint when run under a debugger.

13 Function Definition
Syntax
FunctionDeclaration:
  function Identifier [ FormalParameterList_opt ] { FunctionBody }

FunctionExpression:
  function Identifier_opt [ FormalParameterList_opt ] { FunctionBody }

FormalParameterList:
  Identifier
  FormalParameterList , Identifier

FunctionBody:
  UseStrictDirective_opt SourceElements

Semantics
The production FunctionDeclaration : function Identifier [ FormalParameterList_opt ] { FunctionBody } is processed for function declarations as follows during Declaration Binding instantiation (10.3.3):
1. Create a new Function object as specified in 13.2 with parameters specified by FormalParameterList_opt and body specified by FunctionBody. Pass in the LexicalEnvironment of the running execution context as the Scope.
2. Create a property of the current environment object (as specified in 10.3.3) with name Identifier and value Result(1).

The production FunctionExpression : function ( FormalParameterList_opt ) { FunctionBody } is evaluated as follows:
1. Create a new Function object as specified in 13.2 with parameters specified by FormalParameterList_opt and body specified by FunctionBody. Pass in the LexicalEnvironment of the running execution context as the Scope.
2. Return Result(1).

The production FunctionExpression : function Identifier [ FormalParameterList_opt ] { FunctionBody } is evaluated as follows:
1. Call NewDeclarativeEnvironmentRecord(E) passing the LexicalEnvironment as the argument
2. Call the CreateImmutableBinding(N) concrete method of Result(1) passing the string value of Identifier as the argument.
3. Create a new Function object as specified in 13.2 with parameters specified by FormalParameterList_opt and body specified by FunctionBody. Pass in Result(1) as the Scope.
4. Call the InitializeImmutableBinding(N,V) concrete method of Result(1) passing the string value of Identifier and Result(3) as the arguments.
5. Return Result(3).

NOTE
The Identifier in a FunctionExpression can be referenced from inside the FunctionExpression’s FunctionBody to allow the function to call itself recursively. However, unlike in a FunctionDeclaration, the Identifier in a FunctionExpression cannot be referenced from and does not affect the scope enclosing the FunctionExpression.

The production FunctionBody : SourceElements is evaluated as follows:
1. If the optional UseStrictDirective is present, SourceElements is processed and evaluated in the following steps as strict mode code. Otherwise SourceElements is processed and evaluated in the following steps as non-strict mode code.
3. Evaluate SourceElements.
4. Return Result().

13.1 Definitions
This section is no longer used.

13.2 Creating Function Objects
Given an optional parameter list specified by FormalParameterList, a body specified by FunctionBody, and a lexical environment specified by Scope, a Function object is constructed as follows:

1. Create a new native ECMAScript object and let F be that object.
2. Set the [[Class]] property of F to "function".
3. Set the [[Prototype]] property of F to the original Function prototype object as specified in 15.3.3.1.
4. Set the [[Call]] property of F as described in 13.2.1.
5. Set the [[Construct]] property of F as described in 13.2.2.
6. Set the [[Scope]] property of F to the value of Scope.
7. Set the length property of F to the number of formal parameters specified in FormalParameterList. If no parameters are specified, set the length property of F to 0. This property is given attributes as specified in 15.3.5.1.
8. Set the [[Extensible]] property of F to true.
9. Create a new object as would be constructed by the expression new Object() where Object is the standard built-in constructor with that name.
10. Set the constructor property of Result(9) to F. This property has attributes {[[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true}.
11. Set the prototype property of F to Result(9). This property is given attributes as specified in 15.3.5.2.
12. Return F.

NOTE
A prototype property is automatically created for every function, to allow for the possibility that the function will be used as a constructor.

13.2.1 [[Call]]
When the [[Call]] property for a Function object F is called, the following steps are taken:

1. Establish a new execution context using F's FormalParameterList, the passed arguments list, and the this value as described in 10.1.3.
2. If the Function F is not strict, and the type of this value is not Object, then:
   a. If the this value is null or undefined, replace it with the global object.
   b. Else replace the this value with the result of calling ToObject on the this value.
3. Evaluate F's FunctionBody.
4. Exit the execution context established in step 1, restoring the previous execution context.
5. If Result(3).type is throw then throw Result(3).value.
6. If Result(3).type is return then return Result(3).value.
7. Result(3).type must be normal. Return undefined.

13.2.2 [[Construct]]
When the [[Construct]] property for a Function object F is called, the following steps are taken:

1. Create a new native ECMAScript object.
2. Set the [[Class]] property of Result(1) to "Object".
3. Set the [[Extensible]] property of Result(1) to true.
4. Get the value of the prototype property of F.
5. If Result(4) is an object, set the [[Prototype]] property of Result(1) to Result(4).
6. If Result(4) is not an object, set the [[Prototype]] property of Result(1) to the original Object prototype object as described in 15.2.3.1.
7. Invoke the [[Call]] property of F, providing Result(1) as the this value and providing the argument list passed into [[Construct]] as the argument values.
8. If Type(Result(7)) is Object then return Result(7).
9. Return Result(1).
14 Program

Syntax:

```
Program : UseStrictDirective opt SourceElements

UseStrictDirective opt :
    " use strict useExtension opt " ;

useExtension : , DoubleStringCharacters opt
```

```
SourceElements :
    SourceElement
    SourceElements SourceElement
```

SourceElement :
    Statement
    FunctionDeclaration

Semantics:

The production `Program : UseStrictDirective opt SourceElements` is evaluated as follows:

1. If the optional `UseStrictDirective` is present, `SourceElements` is processed and evaluated in the following steps as strict mode code. Otherwise `SourceElements` is processed and evaluated in the following steps as non-strict mode code.
3. Evaluate `SourceElements`.
4. Return Result(3).

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

1. Process `SourceElement` for function declarations.

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

1. Process `SourceElements` for function declarations.

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

1. Evaluate `SourceElements`.
2. If `Result(1)` is an abrupt completion, return `Result(1)`
3. Evaluate `SourceElement`.
4. Return `Result(3)`.

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 (see clause 13).
The production `SourceElement : FunctionDeclaration` is evaluated as follows:

1. Return `(normal, empty, empty)`.

The productions `UseStrictDirectiveopt : " use strict useExtensionopt " ;` and `useExtensionopt : , DoubleStringCharactersopt` have no associated semantic actions.
15 Native ECMAScript Objects

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

Unless specified otherwise, the [[Class]] property of a built-in object is "Function" if that built-in object has a [[Call]] property, or "Object" if that built-in object does not have a [[Call]] property. Unless specified otherwise, the [[Extensible]] property of a built-in object has the value true.

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. 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 a 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.

Unless otherwise specified in the description of a particular function, if a function or constructor described in this section is given more arguments than the function is specified to allow, the additional arguments are ignored.

NOTE

Implementations that add additional capabilities to the set of built-in functions are encouraged to do so by adding new functions rather than adding new parameters to existing functions.

Every built-in function and every built-in constructor has the Function prototype object, which is the initial value of the expression Function.prototype (15.3.2.1), as the value of its internal [[Prototype]] property.

Every built-in prototype object has the Object prototype object, which is the initial value of the expression Object.prototype (15.3.2.1), as the value of its internal [[Prototype]] property, except the Object prototype object itself.

None of the built-in functions described in this section shall implement the internal [[Construct]] method unless otherwise specified in the description of a particular function. 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 largest number of named arguments shown in the section headings for the function description, including optional parameters.

NOTE

For example, the Function object that is the initial value of the slice property of the String prototype object is described under the section heading "String.prototype.slice (start , end)" which shows the two named arguments start and end; therefore the value of the length property of that Function object is 2.

In every case, the length property of a built-in Function object described in this section has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false } (and no others). Every other property described in this section has the attributes { [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: true } unless otherwise specified.

15.1 The Global Object

The unique global object is created before control enters any execution context.

Unless otherwise specified, the properties of the global object have attributes { [[Enumerable]]: false }.

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.
The global object does not have a `[[Call]]` property; it is not possible to invoke the global object as a function.

The values of the `[[Prototype]]` and `[[Class]]` properties of the global object are implementation-dependent.

In addition to the properties defined in this specification the global object may have additional host defined properties. This may include a property whose value is the global object itself; for example, in the HTML document object model the `window` property of the global object is the global object itself.

15.1.1 Value Properties of the Global Object

15.1.1.1 NaN

The initial value of `NaN` is `NaN` (8.5). This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.1.1.2 Infinity

The initial value of `Infinity` is `+∞` (8.5). This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.1.1.3 undefined

The initial value of `undefined` is `undefined` (8.1). This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

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 a `Program`. If the parse fails, throw a `SyntaxError` exception (but see also clause 16).
3. Evaluate the program from step 2.
4. If Result(3).type is `normal` and its completion value is a value `V`, then return the value `V`.
5. If Result(3).type is `normal` and its completion value is `empty`, then return the value `undefined`.
6. Result(3).type must be `throw`. Throw Result(3).value as an exception.

If the value of the `eval` property is used in any way other than a direct call (that is, other than by the explicit use of its name as an `Identifier` which is the `MemberExpression` in a `CallExpression`), or if the `eval` property is assigned to, an `EvalError` exception may be thrown.

15.1.2.1.1 Strict Mode Restrictions

If an execution context that is subset restricted to the `strict` subset uses the value of the `eval` property any way other than a direct call (that is, other than by the explicit use of its name as an `Identifier` which is the `MemberExpression` in a `CallExpression`), or if the `eval` property is assigned to, an `EvalError` exception is thrown.

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`. Leading white space in the string is ignored. If `radix` is `undefined` or 0, it is assumed to be 10 except when the number begins with the character pairs `0x` or `0X`, in which case a radix of 16 is assumed. Any radix-16 number may also optionally begin with the character pairs `0x` or `0X`.

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

1. Call `ToString(string)`.
2. Let `S` be a newly created substring of Result(1) consisting of the first character that is not a `StrWhiteSpaceChar` and all characters following that character. (In other words, remove leading white space.)
3. Let `sign` be 1.
4. If `S` is not empty and the first character of `S` is a minus sign `−`, let `sign` be −1.
5. If `S` is not empty and the first character of `S` is a plus sign `+` or a minus sign `−`, then remove the first character from `S`.
6. Let `R` = `ToInt32(radix)`.
7. If \( R = 0 \), go to step 11.
8. If \( R < 2 \) or \( R > 36 \), then return \( \text{NaN} \).
9. If \( R = 16 \), go to step 13.
11. Let \( R = 10 \).
12. If the length of \( S \) is at least 1 and the first character of \( S \) is "0", then at the implementation's discretion either let \( R = 8 \) or leave \( R \) unchanged.
13. If the length of \( S \) is at least 2 and the first two characters of \( S \) are either "0x" or "0X", then remove the first two characters from \( S \) and let \( R = 16 \).
14. If \( S \) contains any character that is not a radix-\( R \) digit, then let \( Z \) be the substring of \( S \) consisting of all characters before the first such character; otherwise, let \( Z \) be \( S \).
15. If \( Z \) is empty, return \( \text{NaN} \).
16. Compute the mathematical integer value that is represented by \( Z \) in radix-\( R \) notation, using the letters A-Z and a-z for digits with values 10 through 35. (However, if \( R \) is 10 and \( Z \) contains more than 20 significant digits, every significant digit after the 20th may be replaced by a 0 digit, at the option of the implementation; and if \( R \) is not 2, 4, 8, 10, 16, or 32, then Result(16) may be an implementation-dependent approximation to the mathematical integer value that is represented by \( Z \) in radix-\( R \) notation.)
17. Compute the number value for Result(16).
18. Return \( \text{sign \nobreak} \times \text{Result(17)} \).

**NOTE**

`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.

When radix is 0 or `undefined` and the string's number begins with a 0 digit not followed by an x or X, then the implementation may, at its discretion, interpret the number either as being octal or as being decimal. Implementations are encouraged to interpret numbers in this case as being decimal.

**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 white space.)
3. If neither Result(2) nor any prefix of Result(2) satisfies the syntax of a `StrDecimalLiteral` (see 9.3.1), return `NaN`.
4. Compute the longest prefix of Result(2), which might be Result(2) itself, which satisfies the syntax of a `StrDecimalLiteral`.
5. Return the number value for the MV of Result(4).

**NOTE**

`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 isNaN (number)**

Returns `true` if the result is `NaN`, and otherwise returns `false`.

1. Call `GetValue(number)`.
2. If Type(Result(1)) is Decimal, then
   a. Perform the isFinite method as defined in IEEE 754-2008 with argument Result(1).
   b. Return Result(2a).
3. Call `ToNumber(Result(2))`.
4. If Result(4) is `NaN`, return `true`.
5. Return `false`.

07 November 2008
15.1.2.5 **isFinite (number)**

**Returns** false if the result is NaN, +∞, or −∞, and otherwise returns true.

1. Call GetValue(number).
2. If Type(Result(1)) is Decimal, then
   a. Perform the isFinite method as defined in IEEE 754-2008 with argument Result(1).
   b. Return Result(2a).
3. Call ToNumber(Result(2)).
4. If Result(4) is NaN, +∞, or −∞, return false.
5. Return true.

15.1.3 **URI Handling Function Properties**

Uniform Resource Identifiers, or URIs, are strings that identify resources (e.g. web pages or files) and transport protocols by which to access them (e.g. HTTP or FTP) on the Internet. The ECMAScript language itself does not provide any support for using URIs except for functions that encode and decode URIs as described in 15.1.3.1, 15.1.3.2, 15.1.3.3 and 15.1.3.4.

**NOTE**
Many implementations of ECMAScript provide additional functions and methods that manipulate web pages; these functions are beyond the scope of this standard.

A URI is composed of a sequence of components separated by component separators. The general form is:

\[
\text{Scheme} : \text{First} / \text{Second} ; \text{Third} ? \text{Fourth}
\]

where the italicised names represent components and the “;”, “/”, “;” and “?” are reserved characters used as separators. The `encodeURI` and `decodeURI` functions are intended to work with complete URIs; they assume that any reserved characters in the URI are intended to have special meaning and so are not encoded. The `encodeURIComponent` and `decodeURIComponent` functions are intended to work with the individual component parts of a URI; they assume that any reserved characters represent text and so must be encoded so that they are not interpreted as reserved characters when the component is part of a complete URI.

The following lexical grammar specifies the form of encoded URIs.

```
uri ::= uriCharacters_opt
uriCharacters ::= uriCharacter uriCharacters_opt
uriCharacter ::= uriReserved | uriUnescaped | uriEscaped
uriReserved ::= one of ; / ? : @ & = + $ ,
uriUnescaped ::= uriAlpha | DecimalDigit | uriMark
uriEscaped ::= % HexDigit HexDigit
uriAlpha ::= one of a b c d e f g h i j k l m n o p q r s t u v w x y z A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
```

**Deleted:** Applies ToNumber to its argument, then returns
When a character to be included in a URI is not listed above or is not intended to have the special meaning sometimes given to the reserved characters, that character must be encoded. The character is first transformed into a sequence of octets using the UTF-8 transformation, with surrogate pairs first transformed from their UCS-2 to UCS-4 encodings. (Note that for code points in the range [0, 127] this results in a single octet with the same value.) The resulting sequence of octets is then transformed into a string with each octet represented by an escape sequence of the form \( \text{"\%XX} \).

The encoding and escaping process is described by the hidden function Encode taking two string arguments \text{string} and \text{unescapedSet}. This function is defined for expository purpose only.

1. Compute the number of characters in \text{string}.
2. Let \( R \) be the empty string.
3. Let \( k \) be 0.
4. If \( k \) equals Result(1), return \( R \).
5. Let \( C \) be the character at position \( k \) within \text{string}.
6. If \( C \) is not in \text{unescapedSet}, go to step 9.
7. Let \( S \) be a string containing only the character \( C \).
9. If the code point value of \( C \) is not less than 0xDC00 and not greater than 0xDFFF, throw a URIError exception.
10. If the code point value of \( C \) is less than 0xD800 or greater than 0xDBFF, let \( V \) be the code point value of \( C \) and go to step 16.
11. Increase \( k \) by 1.
12. If \( k \) equals Result(1), throw a URIError exception.
13. Get the code point value of the character at position \( k \) within \text{string}.
14. If Result(13) is less than 0xDC00 or greater than 0xDFFF, throw a URIError exception.
15. Let \( V \) be (((the code point value of \( C \) – 0xD800) * 0x400 + Result(13) – 0xDC00) + 0x10000).
16. Let \text{Octets} be the array of octets resulting by applying the UTF-8 transformation to \( V \), and let \( L \) be the array size.
17. Let \( j \) be 0.
18. Get the value at position \( j \) within \text{Octets}.
19. Let \( S \) be a string containing three characters \( \text{"\%XY} \) where \( XY \) are two uppercase hexadecimal digits encoding the value of Result(18).
20. Let \( R \) be a new string containing three characters \( \text{"\%XY} \) where \( XY \) are two uppercase hexadecimal digits encoding the value of Result(18).
21. Increase \( j \) by 1.
22. If \( j \) is equal to \( L \), go to step 25.
23. Go to step 18.
24. Let \( R \) be a new string containing three characters \( \text{"\%XY} \) where \( XY \) are two uppercase hexadecimal digits encoding the value of Result(18).
25. Increase \( k \) by 1.

The unescaping and decoding process is described by the hidden function Decode taking two string arguments \text{string} and \text{reservedSet}. This function is defined for expository purpose only.

1. Compute the number of characters in \text{string}.
2. Let \( R \) be the empty string.
3. Let \( k \) be 0.
4. If \( k \) equals Result(1), return \( R \).
5. Let \( C \) be the character at position \( k \) within \text{string}.
6. If \( C \) is not \( \text{"\%} \), go to step 40.
7. Let start be \( k \).
8. If \( k + 2 \) is greater than or equal to Result(1), throw a URIError exception.
9. If the characters at position \((k+1)\) and \((k + 2)\) within \text{string} do not represent hexadecimal digits, throw a URIError exception.
10. Let \( B \) be the 8-bit value represented by the two hexadecimal digits at position \((k + 1)\) and \((k + 2)\).
11. Increment \( k \) by 2.
12. If the most significant bit in \( B \) is 0, let \( C \) be the character with code point value \( B \) and go to step 37.
13. Let \( n \) be the smallest non-negative number such that \((B << n) & 0x80\) is equal to 0.
14. If \( n \) equals 1 or \( n \) is greater than 4, throw a \texttt{URIError} exception.
15. Let \( Octets \) be an array of 8-bit integers of size \( n \).
16. Put \( B \) into \( Octets \) at position 0.
17. If \( k + (3 \times (n - 1)) \) is greater than or equal to Result(1), throw a \texttt{URIError} exception.
18. Let \( j \) be 1.
19. If \( j \) equals \( n \), go to step 29.
20. Increment \( k \) by 1.
21. If the character at position \( k \) is not "%", throw a \texttt{URIError} exception.
22. If the characters at position \((k + 1)\) and \((k + 2)\) within \texttt{string} do not represent hexadecimal digits, throw a \texttt{URIError} exception.
23. Let \( B \) be the 8-bit value represented by the two hexadecimal digits at position \((k + 1)\) and \((k + 2)\).
24. If the two most significant bits in \( B \) are not 10, throw a \texttt{URIError} exception.
25. Increment \( k \) by 2.
26. Put \( B \) into \( Octets \) at position \( j \).
27. Increment \( j \) by 1.
28. Go to step 19.
29. Let \( V \) be the value obtained by applying the UTF-8 transformation to \( Octets \), that is, from an array of octets into a 32-bit value.
30. If \( V \) is less than 0x10000, go to step 36.
31. If \( V \) is greater than 0x10FFFF, throw a \texttt{URIError} exception.
32. Let \( I \) be \(((V - 0x10000) & 0x3FF) + 0xDC00)\).
33. Let \( H \) be \(((V - 0x10000) >> 10) & 0x3FF) + 0xD800)\).
34. Let \( S \) be the string containing the two characters with code point values \( H \) and \( I \).
35. Go to step 41.
36. Let \( C \) be the character with code point value \( V \).
37. If \( C \) is not in \texttt{reservedSet}, go to step 40.
38. Let \( S \) be the substring of \texttt{string} from position \texttt{start} to position \texttt{k} included.
39. Go to step 41.
40. Let \( S \) be the string containing only the character \( C \).
41. Let \( R \) be a new string value computed by concatenating the previous value of \( R \) and \( S \).
42. Increase \( k \) by 1.
43. Go to step 4.

\textit{NOTE 1}
\begin{flushleft}
The syntax of Uniform Resource Identifiers is given in RFC2396.
\end{flushleft}

\textit{NOTE 2}
\begin{flushleft}
A formal description and implementation of UTF-8 is given in the Unicode Standard, Version 2.0, Appendix A.
\end{flushleft}

In UTF-8, characters are encoded using sequences of 1 to 6 octets. The only octet of a "sequence" of one has the higher-order bit set to 0, the remaining 7 bits being used to encode the character value. In a sequence of \( n \) octets, \( n \geq 1 \), the initial octet has the \( n \) higher-order bits set to 1, followed by a bit set to 0. The remaining bits of that octet contain bits from the value of the character to be encoded. The following octets all have the higher-order bit set to 1 and the following bit set to 0, leaving 6 bits in each to contain bits from the character to be encoded. The possible UTF-8 encodings of ECMAScript characters are:

<table>
<thead>
<tr>
<th>Code Point Value</th>
<th>Representation</th>
<th>1st Octet</th>
<th>2nd Octet</th>
<th>3rd Octet</th>
<th>4th Octet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x0000 - 0x07FF</td>
<td>00000000 (0)zzzzzz</td>
<td>0zzzzzz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0800 - 0x0FFF</td>
<td>0000(yy) yzzzzzz</td>
<td>110(yy)yy</td>
<td>10zzzzzz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x0800 - 0x7FFF</td>
<td>(xxxxyy) yzzzzzz</td>
<td>1110(xxx)</td>
<td>10(yyyy)yy</td>
<td>10zzzzzz</td>
<td></td>
</tr>
<tr>
<td>0x8000 - 0xDFFF</td>
<td>110110(vu) (v)(u)(u)(u)(u)</td>
<td>1111(uu)</td>
<td>10(uu)(uu)</td>
<td>10(xx)(yy)yy</td>
<td>10zzzzzz</td>
</tr>
</tbody>
</table>

following by

<table>
<thead>
<tr>
<th>Code Point Value</th>
<th>Representation</th>
<th>1st Octet</th>
<th>2nd Octet</th>
<th>3rd Octet</th>
<th>4th Octet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xDC00 - 0xDFFF</td>
<td>110111(yy) yzzzzzz</td>
<td>11111(uu)</td>
<td>10(uu)(uu)</td>
<td>10(xx)(yy)yy</td>
<td>10zzzzzz</td>
</tr>
</tbody>
</table>
98

<table>
<thead>
<tr>
<th>0xD800 - 0xDBFF</th>
<th>not followed by</th>
<th>causes URIError</th>
</tr>
</thead>
<tbody>
<tr>
<td>0xDC00 - 0xDFFF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0xD800 - 0xDBFF</td>
<td>causes URIError</td>
<td></td>
</tr>
<tr>
<td>0xE000 - 0xFFFF</td>
<td>xxxxyyyy yyzzzzzz 1110xxxx 10yyyyyy 10zzzzzz</td>
<td></td>
</tr>
</tbody>
</table>

Where

\[ uuuu = vvvv + 1 \]

to account for the addition of \(0x10000\) as in 3.7. Surrogates of the Unicode Standard version 2.0.

The range of code point values \(0xD800-0xDBFF\) is used to encode surrogate pairs; the above transformation combines a UCS-2 surrogate pair into a UCS-4 representation and encodes the resulting 21-bit value in UTF-8. Decoding reconstructs the surrogate pair.

15.1.3.1 `decodeURI(encodedURI)`

The `decodeURI` function computes a new version of a URI in which each escape sequence and UTF-8 encoding of the sort that might be introduced by the `encodeURI` function is replaced with the character that it represents. Escape sequences that could not have been introduced by `encodeURI` are not replaced.

When the `decodeURI` function is called with one argument `encodedURI`, the following steps are taken:

1. Call ToString(encodedURI).
2. Let `reservedURISet` be a string containing one instance of each character valid in `uriReserved` plus "#".
3. Call Decode(Result(1), reservedURISet)
4. Return Result(3).

**NOTE**
The character "#" is not decoded from escape sequences even though it is not a reserved URI character.

15.1.3.2 `decodeURIComponent(encodedURIComponent)`

The `decodeURIComponent` function computes a new version of a URI in which each escape sequence and UTF-8 encoding of the sort that might be introduced by the `encodeURIComponent` function is replaced with the character that it represents.

When the `decodeURIComponent` function is called with one argument `encodedURIComponent`, the following steps are taken:

1. Call ToString(encodedURIComponent).
2. Let `reservedURIComponentSet` be the empty string.
3. Call Decode(Result(1), reservedURIComponentSet)
4. Return Result(3).

15.1.3.3 `encodeURI(uri)`

The `encodeURI` function computes a new version of a URI in which each instance of certain characters is replaced by one, two or three escape sequences representing the UTF-8 encoding of the character.

When the `encodeURI` function is called with one argument `uri`, the following steps are taken:

1. Call ToString(uri).
2. Let `unescapedURISet` be a string containing one instance of each character valid in `uriReserved` and `uriUnescaped` plus "#".
3. Call Encode(Result(1), unescapedURISet)
4. Return Result(3).
NOTE
The character "#" is not encoded to an escape sequence even though it is not a reserved or unescaped URI character.

15.1.3.4 encodeURIComponent (uriComponent)
The `encodeURIComponent` function computes a new version of a URI in which each instance of certain characters is replaced by one, two or three escape sequences representing the UTF-8 encoding of the character.

When the `encodeURIComponent` function is called with one argument `uriComponent`, the following steps are taken:

1. Call `ToString(uriComponent)`.`
2. Let `unescapedURIComponentSet` be a string containing one instance of each character valid in `uriUnescaped`.
3. Call `Encode(Result(1), unescapedURIComponentSet)`
4. Return Result(3).

15.1.4 Constructor Properties of the Global Object
15.1.4.1 Object (. . .)
See 15.2.1 and 15.2.2.

15.1.4.2 Function (. . .)
See 15.3.1 and 15.3.2.

15.1.4.3 Array (. . .)
See 15.4.1 and 15.4.2.

15.1.4.4 String (. . .)
See 15.5.1 and 15.5.2.

15.1.4.5 Boolean (. . .)
See 15.6.1 and 15.6.2.

15.1.4.6 Number (. . .)
See 15.7.1 and 15.7.2.

15.1.4.7 Date (. . .)
See 15.9.2.

15.1.4.8 RegExp (. . .)
See 15.10.3 and 15.10.4.

15.1.4.9 Error (. . .)
See 15.11.1 and 15.11.2.

15.1.4.10 EvalError (. . .)
See 15.11.6.1.

15.1.4.11 RangeError (. . .)
See 15.11.6.2.

15.1.4.12 ReferenceError (. . .)
See 15.11.6.3.

15.1.4.13 SyntaxError (. . .)
See 15.11.6.4.

15.1.4.14 TypeError (. . .)
See 15.11.6.5.
15.1.4.15 URIError ( . . . )
See 15.11.6.6.

15.1.5 Other Properties of the Global Object

15.1.5.1 Math
See 15.8.

15.1.5.2 JSON
See 15.12.

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 no arguments or with one argument value, the following steps are taken:
1. If value is null, undefined or not supplied, create and return a new Object object exactly if the object constructor had been called with the same arguments (15.2.2.1).
2. Return ToObject(value).

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 no arguments or with one argument value, the following steps are taken:
1. If value is not supplied, go to step 8.
2. If the type of value is not Object, go to step 5.
3. If the value is a native ECMAScript object, do not create a new object but simply return value.
4. 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.
5. If the type of value is String, return ToObject(value).
6. If the type of value is Boolean, return ToObject(value).
7. If the type of value is Number, return ToObject(value).
8. (The argument value was not supplied or its type was 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 [[Extensible]] property of the newly constructed object is set to true.
   The newly constructed object has no [[PrimitiveValue]] property.
9. 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 properties and the length property (whose value is 1), the Object constructor has the following properties:

15.2.3.1 Object.prototype
The initial value of Object.prototype is the Object prototype object (15.2.4).
This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.2.3.2 Object.getPrototypeOf ( O )
When the getPrototypeOf function is called with argument O, the following steps are taken:
1. If Type(O) is not Object throw a TypeError exception.
2. Return the [[Prototype]] property of O.

**15.2.3 Object.getOwnPropertyDescriptor (O, P)**

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

1. If Type(O) is not Object throw a `TypeError` exception.
2. If P is `undefined` or `null`, use the empty string, otherwise call `ToString(P)`.
3. Call the `[[GetOwnProperty]]` method of O with argument Result(2).
4. Call `FromPropertyDescriptor(Result(3))`.
5. Return Result(4).

**15.2.3.4 Object.getOwnPropertyNames (O)**

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

1. If Type(O) is not Object throw a `TypeError` exception.
2. Create a new object as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name.
3. For each named own property P of O
   a. Get the string value that is the name of P.
   b. Call the standard built-in method `Array.prototype.push` on Result(2) with arguments Result(3a).
4. Return Result(2).

**NOTE**
If Result(1) is a String instance, the set of own properties processed in step 3a does not include the implicit properties defined in 15.5.5.2 that correspond to character positions of the object’s `[[PrimitiveValue]]` string.

**15.2.3.5 Object.create (O, Properties)**

The `create` function creates a new object with a specified prototype. When the `create` function is called, the following steps are taken:

1. If Type(O) is not Object throw a `TypeError` exception.
2. Create a new object as if by the expression `new Object()` where `Object` is the standard built-in constructor with that name.
3. Call the standard built-in function `Object.defineProperty` with arguments Result(2) and Properties.
4. Set the internal `[[Prototype]]` property of Result(2) to Result(1).
5. Return Result(4).

**15.2.3.6 Object.defineProperty (O, P, Attributes)**

The `defineOwnProperty` function is used to add an own properties and/or update the attributes of existing own property of an object. When the `defineOwnProperty` function is called, the following steps are taken:

1. If Type(O) is not Object throw a `TypeError` exception.
2. Call `ToString(P)`.
3. Call `ToPropertyDescriptor` with `Result(Attributes)` as the argument.
4. Call the `[[DefineOwnProperty]]` method of O with arguments Result(2), Result(3), and `true`.
5. Return O.

**15.2.3.7 Object.defineProperties (O, Properties)**

The `defineProperties` function is used to add own properties and/or update the attributes of existing own properties of an object. When the `defineProperties` function is called, the following steps are taken atomically:

1. If Type(O) is not Object throw a `TypeError` exception.
2. Call `ToObject(Properties)`.
3. For each named own property name P of Result(2),
   a. Call the `[[GetOwnProperty]]` method of Result(2) with P as the argument.
   b. Call `ToPropertyDescriptor` with Result(3a) as the argument.
   c. Call the `[[DefineOwnProperty]]` method of O with arguments P, Result(3b), `true`.
4. Return O.
The above algorithm is specified as a set of sequential steps that include the possibility of an exception being thrown as various intermediate points. Rather than failing after a partial update of O, this function must be implemented such that it either atomically completes all property updates successfully or fails without making any update to the properties of object O.

15.2.3.8 `Object.seal (O)`
When the `seal` function is called, the following steps are taken:
1. If `Type(O)` is not `Object` throw a `TypeError` exception.
2. For each named own property name `P` of `O`,
   a. Call the `[[GetOwnProperty]]` method of `O` with `P`.
      b. If `Result(2a).[[Configurable]]` is `true`, set `Result(2a).[[Configurable]]` to `false`.
      c. Call the `[[DefineOwnProperty]]` method of `O` with `P`, `Result(2a)`, and `true` as arguments.
3. Set the internal `[[Extensible]]` property of `O` to `false`.
4. Return `O`.

The above algorithm is specified as a set of sequential steps that include the possibility of a exception being thrown as various intermediate points. Rather than failing after a partial update of `O`, this function must be implemented such that it either atomically completes all property updates successfully or fails without making any update to the properties of object `O`.

15.2.3.9 `Object.freeze (O)`
When the `freeze` function is called, the following steps are taken:
1. If `Type(O)` is not `Object` throw a `TypeError` exception.
2. For each named own property name `P` of `O`,
   a. Call the `[[GetOwnProperty]]` method of `O` with `P`.
      b. If `IsDataDescriptor(Result(2a))` then
         i. If `Result(2a).[[Writable]]` is `true`, set `Result(2a).[[Writable]]` to `false`.
      c. If `Result(2a).[[Configurable]]` is `true`, set `Result(2a).[[Configurable]]` to `false`.
      d. Call the `[[DefineOwnProperty]]` method of `O` with `P`, `Result(2a)`, and `true` as arguments.
3. Set the internal `[[Extensible]]` property of `O` to `false`.
4. Return `O`.

The above algorithm is specified as a set of sequential steps that include the possibility of a exception being thrown as various intermediate points. Rather than failing after a partial update of `O`, this function must be implemented such that it either atomically completes all property updates successfully or fails without making any update to object `O`.

15.2.3.10 `Object.preventExtensions (O)`
When the `preventExtensions` function is called, the following steps are taken:
5. If `Type(O)` is not `Object` throw a `TypeError` exception.
6. Set the internal `[[Extensible]]` property of `O` to `false`.
7. Return `O`.

15.2.3.11 `Object.isSealed (O)`
When the `isSealed` function is called with argument `O`, the following steps are taken:
1. If `Type(O)` is not `Object` throw a `TypeError` exception.
2. For each named own data property `P` of `O`,
   a. Call the `[[GetOwnProperty]]` method of `O` with `P`.
   b. If the `[[Configurable]]` field of `Result(2a)` is `true`, return `false`.
3. If the internal `[[Extensible]]` property of `O` is `false`, then return `true`.
4. Otherwise, return `false`.

15.2.3.12 `Object.isFrozen (O)`
When the `isFrozen` function is called with argument `O`, the following steps are taken:
1. If `Type(O)` is not `Object` throw a `TypeError` exception.
2. For each named own data property name `P` of `O`,
   a. Call the `[[GetOwnProperty]]` method of `O` with `P`.
   b. If `IsDataDescriptor(Result(2a))` then
1. If Result(2a).[[Writable]] is true, return false.
2. If the [[Configurable]] field of Result(2a) is true, then return false.
3. If the internal [[Extensible]] property of $O$ is true, then return false.
4. Otherwise, return true.

15.2.3.13 Object.isExtensible (O)
When the isExtensible function is called with argument $O$, the following steps are taken:
1. If Type($O$) is not Object throw a TypeError exception.
2. Return the Boolean value of the internal [[Extensible]] property of $O$.

15.2.3.14 Object.keys (O, fast)
When the keys function is called with argument $O$, the following steps are taken:
1. If the Type($O$) is not Object, throw a TypeError exception.
2. Create a new array as if by the expression new Array() where Array is the standard built-in constructor with that name.
3. For each own enumerable property of $O$, append the key string of the property to Result(2).
4. Call ToBoolean(fast).
5. If Result(4) is false, then sort the array by Result(2).sort().
6. Return Result(2).

15.2.4 Properties of the Object Prototype Object
The value of the internal [[Prototype]] property of the Object prototype object is null, the value of the internal [[Class]] property is "Object", and the value of the internal [[Extensible]] property is true.

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. Let $O$ be the result of calling ToObject passing the this object as the argument.
2. Get the [[Class]] property of $O$.
3. Compute a string value by concatenating the three strings "[object ", Result(2), and "]".
4. Return Result(3).

15.2.4.3 Object.prototype.toLocaleString ()
When the toLocaleString method is called, the following steps are taken:
1. Let $O$ be the result of calling ToObject passing the this object as the argument.
2. Call the [[Get]] internal method of $O$ passing "toString" as the argument.
3. If IsCallable(Result(2)) is false, throw a TypeError exception.
4. Call the [[Call]] internal method of Result(2) passing $O$ as the this value and no arguments.
5. Return Result(4).

NOTE 1
This function is provided to give all Objects a generic toLocaleString interface, even though not all may use it. Currently, Array, Number, and Date provide their own locale-sensitive toLocaleString methods.

NOTE 2
The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

15.2.4.4 Object.prototype.valueOf ()
The valueOf method returns its this value. If the object is the result of calling the Object constructor with a host object (15.2.2.1), it is implementation-defined whether valueOf returns its this value or another value such as the host object originally passed to the constructor.

15.2.4.5 Object.prototype.hasOwnProperty (V)
When the hasOwnProperty method is called with argument V, the following steps are taken:

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1. Let O be the result of calling ToObject passing the this object as the argument.
2. Call ToString(V).
3. Call the [[GetOwnProperty]] internal method of O passing Result(2) as the argument.
4. If Result(3) is undefined, return false.
5. Return true.

**NOTE**
Unlike [[HasProperty]] (8.6.2.4), this method does not consider objects in the prototype chain.

### 15.2.4.6 Object.prototype.isPrototypeOf (V)

When the isPrototypeOf method is called with argument V, the following steps are taken:

1. Let O be the result of calling ToObject passing the this object as the argument.
2. If V is not an object, return false.
3. Let V be the value of the [[Prototype]] property of V.
4. If V is null, return false.
5. If O and V refer to the same object, return true.
6. Go to step 3.

### 15.2.4.7 Object.prototype.propertyIsEnumerable (V)

When the propertyIsEnumerable method is called with argument V, the following steps are taken:

1. Let O be the result of calling ToObject passing the this object as the argument.
2. Call ToString(V).
3. Call the [[GetOwnProperty]] internal method of O passing Result(2) as the argument.
4. If Result(3) is undefined, return false.
5. Return the value of Result(3).[[Enumerable]].

**NOTE**
This method does not consider objects in the prototype chain.

### 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 initialises 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, and where body might also not be provided), the following steps are taken:

1. Create and return a new Function object as if the standard built-in constructor Function was used in a new expression with the same arguments (15.3.2.1).

#### 15.3.2 The Function Constructor

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

#### 15.3.2.1 new 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, and where body might also not be provided), the following steps are taken:
1. Let \( P \) be the empty string.
2. If no arguments were given, let \( \text{body} \) be the empty string and go to step 13.
3. If one argument was given, let \( \text{body} \) be that argument and go to step 13.
4. Let \( \text{Result}(4) \) be the first argument.
5. Let \( P \) be \( \text{ToString}(\text{Result}(4)) \).
6. Let \( k \) be 2.
7. If \( k \) equals the number of arguments, let \( \text{body} \) be the \( k \)th argument and go to step 13.
8. Let \( \text{Result}(8) \) be the \( k \)th argument.
9. Call \( \text{ToString}(\text{Result}(8)) \).
10. Let \( P \) be the result of concatenating the previous value of \( P \), the string "," (a comma), and \( \text{Result}(9) \).
11. Increase \( k \) by 1.
13. Call \( \text{ToString}(\text{body}) \).
14. If \( P \) is not parsable as a \( \text{FormalParameterList}_\text{opt} \), then throw a \text{SyntaxError} exception.
15. If \( \text{body} \) is not parsable as \( \text{FunctionBody} \), then throw a \text{SyntaxError} exception.
16. Create a new Function object as specified in 13.2 with parameters specified by parsing \( P \) as a \( \text{FormalParameterList}_\text{opt} \) and body specified by parsing \( \text{body} \) as a \( \text{FunctionBody} \). Pass in the \text{Global Environment} as the \text{Scope} parameter.
17. Call the \([\text{Put}]\) method of \( \text{Result}(16) \) with arguments "name" and "".
18. Return \( \text{Result}(16) \).

A \text{prototype} property is automatically created for every function, to provide for the possibility that the function will be used as a constructor.

**NOTE**
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:

\[
\text{new Function("a", "b", "c", "return a+b+c")}
\]
\[
\text{new Function("a,b", "c", "return a+b+c")}
\]
\[
\text{new Function("a\,b", "c", "return a+b+c")}
\]

### 15.3.3 Properties of the Function Constructor
The value of the internal \([\text{Prototype}]\) property of the Function constructor is the Function prototype object (15.3.4).

The value of the internal \([\text{Extensible}]\) property of the Function constructor is \text{true}. The \text{Function} constructor has the following properties:

#### 15.3.3.1 \text{Function.prototype}
The initial value of \text{Function.prototype} is the Function prototype object (15.3.4).

This property has the attributes \{ \([\text{Writable}]: \text{false}, [\text{Enumerable}]: \text{false}, [\text{Configurable}]: \text{false} \} \}.

#### 15.3.3.2 \text{Function.length}
The is a data property with an initial value of 1. This property has the attributes \{ \([\text{Writable}]: \text{false}, [\text{Enumerable}]: \text{false}, [\text{Configurable}]: \text{false} \} \}.

### 15.3.4 Properties of the Function Prototype Object
The Function prototype object is itself a Function object (its \([\text{Class}]\) is "Function") that, when invoked, accepts any arguments and returns \text{undefined}.

The value of the internal \([\text{Prototype}]\) property of the Function prototype object is the Object prototype object (15.3.2.1). The initial value of the internal \([\text{Extensible}]\) property of the Function prototype object is \text{true}.

It is a function with an "empty body"; if it is invoked, it merely returns \text{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 white space, line terminators, and semicolons within the representation string is implementation-dependent.

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

15.3.4.3 `Function.prototype.apply(thisArg, argArray)`

The `apply` method takes two arguments, `thisArg` and `argArray`, and performs a function call using the `[[Call]]` property of the object. If the object does not have a `[[Call]]` property, a `TypeError` exception is thrown.

The called function is passed `thisArg` as the `this` value.

If `argArray` is `null` or `undefined`, the called function is passed no arguments. Otherwise, if `argArray` is neither an array nor an arguments object (see 10.4.2), a `TypeError` exception is thrown. If `argArray` is either an array or an arguments object, the function is passed the (`ToUint32(argArray.length)`) arguments `argArray[0], argArray[1], ..., argArray[ToUint32(argArray.length)−1]`.

The `length` property of the `apply` method is 2.

15.3.4.4 `Function.prototype.call(thisArg, arg1, arg2, ...)`

The `call` method takes one or more arguments, `thisArg` and (optionally) `arg1`, `arg2` etc, and performs a function call using the `[[Call]]` property of the object. If the object does not have a `[[Call]]` property, a `TypeError` exception is thrown. The called function is passed `arg1`, `arg2`, etc, as the arguments.

The called function is passed `thisArg` as the `this` value.

1. The `length` property of the `call` method is 1.

15.3.4.5 `Function.prototype.bind(thisArg, arg1, arg2, ...)`

The `bind` method takes one or more arguments, `thisArg` and (optionally) `arg1`, `arg2`, etc, and returns a new function object by performing the following steps:

1. Let `T` be `thisArg`.
2. Let `G` be the `this` object.
3. If `isCallable(G)` is `false`, throw a `TypeError` exception.
4. Let `A` be a new (possibly empty) internal list of all of the argument values provided after `thisArg` (arg1, arg2 etc), in order.
5. Create a new native ECMAScript object and let `F` be that object.
6. Set the `[[Class]]` property of `F` to "Function".
7. Set the `[[Prototype]]` property of `F` to the original Function prototype object as specified in 15.3.3.1.
8. Set the `[[Call]]` property of `F` as described in 15.3.4.5.1.
9. Set the `[[Construct]]` property of `F` as described in 15.3.4.5.2.
10. The `[[Scope]]` property of `F` has no observable effect, and so can be ignored.
11. If the `[[Class]]` property of `G` is "Function", then
   a. Get the `length` property of `G`.
   b. Let `L` be `Result(11a)` minus the length of `A`.
   c. Set the `length` property of `F` to either 0 or `L`, whichever is larger.
12. Else set the `length` property of `F` to 0.
13. The length property of `F` is given attributes as specified in 15.3.5.1.
14. Set the `[[Extensible]]` property of `F` to `true`.
15. If the `[[Class]]` property of `G` is "Function", then
   a. Get the `prototype` property of `G`.

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b. Set the prototype property of \( F \) to Result(15a).

16. Else
   a. Create a new object as would be constructed by the expression \texttt{new Object()} where \texttt{Object} is the standard built-in constructor with that name.
   b. Set the constructor property of Result(16a) to \( F \). This property has attributes {
      \[
      \text{[[Writable]]}: \text{true}, \text{[[Enumerable]]}: \text{false}, \text{[[Configurable]]}: \text{true}
      \]
   c. Set the prototype property of \( F \) to Result(16a).

17. The prototype property of \( F \) is given attributes as specified in 15.3.5.2.

18. Return \( F \).

15.3.4.5.1 \texttt{[[Call]]}
When executed with zero or more arguments, \( F \) uses the values of \( T, G \) and \( A \) that were associated with it at its creation, and the following steps are taken:
1. Let \( \text{Args} \) be a new internal list containing the same values as the list \( A \) in the same order followed by the argument list passed to \( F \) in the same order.
2. Invoke the \texttt{[[Call]]} method of \( F \) providing \( T \) as the \texttt{this} value and providing \( \text{Args} \) as the arguments.
3. Return Result(3).

15.3.4.5.2 \texttt{[[Construct]]}
When executed with zero or more arguments, \( F \) uses the values of \( G \) and \( A \) that were associated with it at its creation, and the following steps are taken:
1. If \( G \) has no \texttt{[[Construct]]} method, a TypeError exception is thrown.
2. Let \( \text{Args} \) be a new internal list containing the same values as the list \( A \) in the same order followed by the argument list passed to \( F \) in the same order.
3. Invoke the \texttt{[[Construct]]} method of \( F \) providing undefined as the \texttt{this} value and providing \( \text{Args} \) as the arguments.
4. Return Result(3).

15.3.5 Properties of Function Instances
In addition to the required internal properties, every function instance has a \texttt{[[Call]]} property, a \texttt{[[Construct]]} property and a \texttt{[[Scope]]} property (see 8.6.2 and 13.2). The value of the \texttt{[[Class]]} property is "Function".

15.3.5.1 \texttt{length}
The value of the \texttt{length} property is 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 behaviour of a function when invoked on a number of arguments other than the number specified by its \texttt{length} property depends on the function. This property has the attributes {
\[
\text{[[Writable]]}: \text{false}, \text{[[Enumerable]]}: \text{false}, \text{[[Configurable]]}: \text{false}
\].

15.3.5.2 \texttt{prototype}
The value of the \texttt{prototype} property is used to initialise the internal \texttt{[Prototype]} property of a newly created object before the Function object is invoked as a constructor for that newly created object. This property has the attribute {
\[
\text{[[Writable]]}: \text{true}, \text{[[Enumerable]]}: \text{false}, \text{[[Configurable]]}: \text{false}
\].

15.3.5.3 \texttt{[[HasInstance]]}(V)
Assume \( F \) is a Function object.
When the \texttt{[[HasInstance]]} method of \( F \) is called with value \( V \), the following steps are taken:
1. If \( V \) is not an object, return \texttt{false}.
2. Call the \texttt{[[Get]]} method of \( F \) with property name \texttt{"prototype"}.
3. Let \( O \) be Result(2).
4. If \( O \) is not an object, throw a TypeError exception.
5. Let \( V \) be the value of the \texttt{[[Prototype]]} property of \( V \).
6. If \( V \) is \texttt{null}, return \texttt{false}.
7. If \( O \) and \( V \) refer to the same object, return \texttt{true}.
8. Go to step 5.

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15.3.5.4 name

The value of the name property is the name of the function, or an empty string if the function is anonymous. This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: true, [[Configurable]]: false }.

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 a nonnegative integer less than \( 2^{32} \). The value of 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 Called as a Function

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

15.4.1.1 `Array([item1[,item2[,\ldots]]])`

When the `Array` function is called the following steps are taken:

1. Create and return a new Array object exactly as if the standard built-in constructor `Array` was used in a `new` expression with the same arguments (15.4.2).

15.4.2 The Array Constructor

When `Array` is called as part of a `new` expression, it is a constructor; it initialises the newly created object.

15.4.2.1 `new Array([item0[,item1[,\ldots]]])`

This description applies if and only if the Array constructor is given no arguments or at least two arguments.

The `[[Prototype]]` property of the newly constructed object is set to the original Array prototype object, the one that is the initial value of `Array.prototype` (15.4.3.1).

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

The `[[Extensible]]` property of the newly constructed object is set to `true`.

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` (if supplied); the `1` property of the newly constructed object is set to `item1` (if supplied); 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`.

15.4.2.2 `new Array(len)`

The `[[Prototype]]` property of the newly constructed object is set to the original Array prototype object, the one that is the initial value of `Array.prototype` (15.4.3.1). The `[[Class]]` property of the newly constructed object is set to "Array". The `[[Extensible]]` property of the newly constructed object is set to `true`.

If the argument `len` is a Number and `ToUint32(len)` is equal to `len`, then the `length` property of the newly constructed object is set to `ToUint32(len)`. If the argument `len` is a Number and `ToUint32(len)` is not equal to `len`, a `RangeError` exception is thrown.

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If the argument \( \text{len} \) is not a Number, then the \( \text{length} \) property of the newly constructed object is set to 1 and the 0 property of the newly constructed object is set to \( \text{len} \).

### 15.4.3 Properties of the Array Constructor

The value of the internal \([\text{Prototype}]\) property of the Array constructor is the Function prototype object (15.3.4).

Besides the internal properties and the \( \text{length} \) property (whose value is 1), the Array constructor has the following properties:

#### 15.4.3.1 Array.prototype

The initial value of Array.prototype is the Array prototype object (15.4.4). This property has the attributes \{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false \}.

#### 15.4.3.2 Array.isArray (arg)

The isArray function takes one argument \( \text{arg} \), and returns the Boolean value true if the argument is an object whose [[Class]] internal property has the string value "Array"; otherwise it return false.

### 15.4.4 Properties of the Array Prototype Object

The value of the internal [[Prototype]] property of the Array prototype object is the Object prototype object (15.2.3.1). The Array prototype object is itself an array; its [[Class]] is "Array", and it has a length property (whose initial value is +0) and the special internal [[ThrowablePut]] method described in 15.4.5.1.

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 the this to be an object for which the value of the internal [[Class]] property is not "Array".

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

#### 15.4.4.1 Array.prototype.constructor

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

#### 15.4.4.2 Array.prototype.toString ()

The result of calling this function is the same as if the standard built-in method Array.prototype.join were invoked for this object with no argument.

The toString function is not generic; it throws a TypeError exception if its this value is not an Array object. Therefore, it cannot be transferred to other kinds of objects for use as a method.

#### 15.4.4.3 Array.prototype.toLocaleString ()

The elements of the array are converted to strings using their toLocaleString methods, and these strings are then concatenated, separated by occurrences of a separator string that has been derived in an implementation-defined locale-specific way. The result of calling this function is intended to be analogous to the result of toString, except that the result of this function is intended to be locale-specific.

The result is calculated as follows:

1. Call the [[Get]] method of this object with argument "length".
2. Call ToUint32(Result(1)).
3. Let separator be the list-separator string appropriate for the host environment’s current locale (this is derived in an implementation-defined way).
4. Call ToString(separator).
5. If Result(2) is zero, 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 ToObject(Result(6)).toLocaleStrings().
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 \([\text{Get}]\) method of this object with argument ToString(\( k \)).
13. If Result(12) is \texttt{undefined} or \texttt{null}, use the empty string; otherwise, call ToObject(Result(12)).toLocaleString().
14. Let \( R \) be a string value produced by concatenating \( S \) and Result(13).
15. Increase \( k \) by 1.

The \texttt{toLocaleString} function is not generic; it throws a \texttt{TypeError} exception if its \texttt{this} value is not an Array object. Therefore, it cannot be transferred to other kinds of objects for use as a method.

\textbf{NOTE}
The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

\subsection{15.4.4.4} \texttt{Array.prototype.concat ( [ item1 [ , item2 [ , ... ] ] ] )}

When the \texttt{concat} method is called with zero or more arguments \texttt{item1}, \texttt{item2}, etc., it returns an array containing the array elements of the object followed by the array elements of each argument in order.

The following steps are taken:
1. Let \( A \) be a new array created as if by the expression \texttt{new Array()} \texttt{where Array} is the standard built-in constructor with that name.
2. Let \( n \) be 0.
3. Let \( E \) be this object.
4. If \( E \) is not an Array object, go to step 16.
5. Let \( k \) be 0.
6. Call the \([\text{Get}]\) method of \( E \) with argument \texttt{"length"}.
7. If \( k \) equals Result(6) go to step 19.
8. Call ToString(\( k \)).
9. If \( E \) has a property named by Result(8), go to step 10, but if \( E \) has no property named by Result(8), go to step 13.
10. Call ToString(\( n \)).
11. Call the \([\text{Get}]\) method of \( E \) with argument Result(8).
12. Call the \([\text{Put}]\) method of \( A \) with arguments Result(10) and Result(11).
13. Increase \( n \) by 1.
14. Increase \( k \) by 1.
15. Go to step 7.
16. Call ToString(\( n \)).
17. Call the \([\text{Put}]\) method of \( A \) with arguments Result(16) and \( E \).
18. Increase \( n \) by 1.
19. Get the next argument in the argument list; if there are no more arguments, go to step 22.
20. Let \( E \) be Result(19).
22. Call the \([\text{Put}]\) method of \( A \) with arguments \texttt{"length"} and \( n \).
23. Return \( A \).

The \texttt{length} property of the \texttt{concat} method is 1.

\textbf{NOTE}
The \texttt{concat} function is intentionally generic; it does not require that its \texttt{this} value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the \texttt{concat} function can be applied successfully to a host object is implementation-dependent.

\subsection{15.4.4.5} \texttt{Array.prototype.join (separator)}

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

The \texttt{join} method takes one argument, \texttt{separator}, and performs the following steps:

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1. Call the [[Get]] method of this object with argument "length".
2. Call ToUint32(Result(1)).
3. If separator is undefined, let separator be the single-character string ",".
4. Call ToString(separator).
5. If Result(2) is zero, 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 ToString(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.

The length property of the join method is 1.

NOTE
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. Whether the join function can be applied successfully to a host object is implementation-dependent.

15.4.4.6 Array.prototype.pop ( )
The last element of the array is removed from the array and returned.
1. Call the [[Get]] method of this object with argument "length".
2. Call ToUint32(Result(1)).
3. If Result(2) is not zero, go to step 6.
4. Call the [[Put]] method of this object with arguments "length" and Result(2).
5. Return undefined.
6. Call ToString(Result(2)–1).
7. Call the [[Get]] method of this object with argument Result(6).
8. Call the [[Delete]] method of this object with argument Result(6).
9. Call the [[Put]] method of this object with arguments "length" and (Result(2)–1).
10. Return Result(7).

NOTE
The pop 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. Whether the pop function can be applied successfully to a host object is implementation-dependent.

15.4.4.7 Array.prototype.push ( [ item1 , item2 , ... ] )
The arguments are appended to the end of the array, in the order in which they appear. The new length of the array is returned as the result of the call.
When the push method is called with zero or more arguments item1, item2, etc., the following steps are taken:
1. Call the [[Get]] method of this object with argument "length".
2. Let n be the result of calling ToUint32(Result(1)).
3. Get the next argument in the argument list; if there are no more arguments, go to step 7.
4. Call the [[Put]] method of this object with arguments ToString(n) and Result(3).
5. Increase n by 1.
6. Go to step 3.
7. Call the [[Put]] method of this object with arguments "length" and n.
8. Return n.

The length property of the push method is 1.
NOTE
The `push` 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. Whether the `push` function can be applied successfully to a host object is implementation-dependent.

### 15.4.4.8 `Array.prototype.reverse()`

The elements of the array are rearranged so as to reverse their order. The 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 `ToString(k)`.
8. Call `ToString(Result(6))`.
9. Call the `[[Get]]` method of this object with argument `Result(7)`.
10. Call the `[[Get]]` method of this object with argument `Result(8)`.
11. If this object does not have a property named by `Result(8)`, go to step 19.
12. If this object does not have a property named by `Result(7)`, go to step 16.
13. Call the `[[Put]]` method of this object with arguments `Result(7)` and `Result(10)`.
14. Call the `[[Put]]` method of this object with arguments `Result(8)` and `Result(9)`.
15. Go to step 25.
16. Call the `[[Put]]` method of this object with arguments `Result(7)` and `Result(10)`.
17. Call the `[[Delete]]` method on this object, providing `Result(8)` as the name of the property to delete.
18. Go to step 25.
19. If this object does not have a property named by `Result(7)`, go to step 23.
20. Call the `[[Delete]]` method on this object, providing `Result(7)` as the name of the property to delete.
21. Call the `[[Put]]` method of this object with arguments `Result(8)` and `Result(9)`.
22. Go to step 25.
23. Call the `[[Delete]]` method on this object, providing `Result(7)` as the name of the property to delete.
24. Call the `[[Delete]]` method on this object, providing `Result(8)` as the name of the property to delete.
25. Increase `k` by 1.
26. Go to step 5.

NOTE
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. Whether the `reverse` function can be applied successfully to a host object is implementation-dependent.

### 15.4.4.9 `Array.prototype.shift()`

The first element of the array is removed from the array and returned.

1. Call the `[[Get]]` method of this object with argument "length".
2. Call `ToUint32(Result(1)).`
3. If `Result(2)` is not zero, go to step 6.
4. Call the `[[Put]]` method of this object with arguments "length" and `Result(2)`.
5. Return `undefined`.
6. Call the `[[Get]]` method of this object with argument `0`.
7. Let `k` be 1.
8. If `k` equals `Result(2)`, go to step 18.
9. Call `ToString(k)`.
10. Call `ToString(k-1)`.

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11. If this object has a property named by `Result(9)`, go to step 12; but if this object has no property named by `Result(9)`, then go to step 15.
12. Call the `[[Get]]` method of this object with argument `Result(9)`.
13. Call the `[[Put]]` method of this object with arguments `Result(10)` and `Result(12)`.
14. Go to step 16.
15. Call the `[[Delete]]` method of this object with argument `Result(10)`.
16. Increase `k` by 1.
17. Go to step 8.
18. Call the `[[Delete]]` method of this object with argument `ToString(Result(2)–1)`.
19. Call the `[[Put]]` method of this object with arguments “`length`” and `Result(2)–1`.
20. Return `Result(6)`.

**NOTE**
The `shift` 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. Whether the `shift` function can be applied successfully to a host object is implementation-dependent.

### 15.4.4.10 Array.prototype.slice (start, end)

The `slice` method takes two arguments, `start` and `end`, and returns an array containing the elements of the array from element `start` up to, but not including, element `end` (or through the end of the array if `end` is `undefined`). If `start` is negative, it is treated as `(length+start)` where `length` is the length of the array. If `end` is negative, it is treated as `(length+end)` where `length` is the length of the array. The following steps are taken:

1. Let `A` be a new array created as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name.
2. Call the `[[Get]]` method of this object with argument “`length`”.
3. Call `ToUint32(Result(2))`.
4. Call `ToInteger(start)`.
5. If `Result(4)` is negative, use `max((Result(3)+Result(4)),0)`; else use `min(Result(4),Result(3))`.
6. Let `k` be `Result(5)`.
7. If `end` is `undefined`, use `Result(3)`; else use `ToInteger(end)`.
8. If `Result(7)` is negative, use `max((Result(3)+Result(7)),0)`; else use `min(Result(7),Result(3))`.
9. Let `n` be 0.
10. If `k` is greater than or equal to `Result(8)`, go to step 19.
11. Call `ToString(k)`.
12. If this object has a property named by `Result(11)`, go to step 13; but if this object has no property named by `Result(11)`, then go to step 16.
13. Call `ToString(n)`.
14. Call the `[[Get]]` method of this object with argument `Result(11)`.
15. Call the `[[Put]]` method of `A` with arguments `Result(13)` and `Result(14)`.
16. Increase `k` by 1.
17. Increase `n` by 1.
18. Go to step 10.
19. Call the `[[Put]]` method of `A` with arguments “`length`” and `n`.
20. Return `A`.

The `length` property of the `slice` method is 2.

**NOTE**
The `slice` 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. Whether the `slice` function can be applied successfully to a host object is implementation-dependent.

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

The elements of this array are sorted. The sort is not necessarily stable (that is, elements that compare equal do not necessarily remain in their original order). If `comparefn` is not `undefined`, 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`.

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If `comparefn` is not `undefined` and is not a consistent comparison function for the elements of this array (see below), the behaviour of `sort` is implementation-defined. Let `len` be `ToUint32(this.length)`. If there exist integers `i` and `j` and an object `P` such that all of the conditions below are satisfied then the behaviour of `sort` is implementation-defined:

\[
\begin{align*}
0 & \leq i < len \\
0 & \leq j < len \\
\text{this} & \text{ does not have a property with name `ToString(i)`} \\
P & \text{ is obtained by following one or more `[[Prototype]]` properties starting at `this`} \\
P & \text{ has a property with name `ToString(j)`}
\end{align*}
\]

Otherwise the following steps are taken.

1. Call the `[[Get]]` method of this object with argument "length".
2. Call `To Uint32(Result(1))`.
3. Perform an implementation-dependent sequence of calls to the `[[Get]]`, `[[Put]]`, and `[[Delete]]` methods of this object and to SortCompare (described below), where the first argument for each call to `[[Get]]`, `[[Put]]`, or `[[Delete]]` is a nonnegative integer less than `Result(2)` and where the arguments for calls to SortCompare are results of previous calls to the `[[Get]]` method.
4. Return this object.

The returned object must have the following two properties.

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)`, if property \( \text{old}[j] \) existed, then

\[
\text{new[π(j)]} \text{ is exactly the same value as } \text{old}[j].
\]

If property \( \text{old}[j] \) did not exist, then \( \text{new[π(j)]} \) does not exist.

Then for all nonnegative integers \( j \) and \( k \), each less than `Result(2)`, if `SortCompare(j,k) < 0` (see SortCompare below), then \( \pi(j) < \pi(k) \).

Here the notation \( \text{old}[j] \) is used to refer to the hypothetical result of calling the `[[Get]]` method of this object with argument \( j \) before this function is executed, and the notation \( \text{new}[j] \) to refer to the hypothetical result of calling the `[[Get]]` method of this object with argument \( j \) after this function has been executed.

A function `comparefn` is a consistent comparison function for a set of values \( S \) if all of the requirements below are met for all values \( a \), \( b \), and \( c \) (possibly the same value) in the set \( S \): The notation \( a \prec_S b \) means \( \text{comparefn}(a,b) < 0 \); \( a \equiv_S b \) means \( \text{comparefn}(a,b) = 0 \) (of either sign); and \( a \succ_S b \) means \( \text{comparefn}(a,b) > 0 \).

Calling `comparefn(a,b)` always returns the same value \( v \) when given a specific pair of values \( a \) and \( b \) as its two arguments. Furthermore, \( v \) has type Number, and \( v \) is not NaN. Note that this implies that exactly one of \( a \prec_S b \), \( a \equiv_S b \), and \( a \succ_S b \) will be true for a given pair of \( a \) and \( b \).

\[
\begin{align*}
\text{a } & \equiv_S a \quad \text{(reflexivity)} \\
\text{If } a & \prec_S b \text{, then } b \equiv_S a \quad \text{(symmetry)} \\
\text{If } a & \equiv_S b \text{ and } b \equiv_S c \text{, then } a \equiv_S c \quad \text{(transitivity of } \equiv_S) \\
\text{If } a & \prec_S b \text{ and } b \prec_S c \text{, then } a \prec_S c \quad \text{(transitivity of } \prec_S) \\
\text{If } a & \succ_S b \text{ and } b \succ_S c \text{, then } a \succ_S c \quad \text{(transitivity of } \succ_S)
\end{align*}
\]

**NOTE**

The above conditions are necessary and sufficient to ensure that `comparefn` divides the set \( S \) into equivalence classes and that these equivalence classes are totally ordered.

When the SortCompare operator is called with two arguments \( j \) and \( k \), the following steps are taken:

1. Call `ToString(j)`.
2. Call `ToString(k)`.
3. If this object does not have a property named by `Result(1)`, and this object does not have a property named by `Result(2)`, return `+0`.

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4. If this object does not have a property named by Result(1), return 1.
5. If this object does not have a property named by Result(2), return –1.
6. Call the [[Get]] method of this object with argument Result(1).
7. Call the [[Get]] method of this object with argument Result(2).
8. Let x be Result(6).
9. Let y be Result(7).
10. If x and y are both undefined, return +0.
11. If x is undefined, return 1.
12. If y is undefined, return –1.
13. If the argument comparefn is undefined, go to step 16.
14. Call comparefn with arguments x and y.
15. Return Result(14).
16. Call ToString(x).
17. Call ToString(y).
20. Return +0.

NOTE 1
Because non-existent property values always compare greater than undefined property values, and undefined always compares greater than any other value, undefined property values always sort to the end of the result, followed by non-existent property values.

NOTE 2
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. Whether the sort function can be applied successfully to a host object is implementation-dependent.

15.4.4.12 Array.prototype.splice (start, deleteCount [ , item1 [ , item2 [ , … ] ] ] )

When the splice method is called with two or more arguments start, deleteCount and (optionally) item1, item2, etc., the deleteCount elements of the array starting at array index start are replaced by the arguments item1, item2, etc. The following steps are taken:

1. Let A be a new array created as if by the expression new Array() where Array is the standard built-in constructor with that name.
2. Call the [[Get]] method of this object with argument "length".
3. Call ToUint32(Result(2)).
4. Call ToInteger(start).
5. If Result(4) is negative, use max((Result(3)+Result(4)),0); else use min(Result(4),Result(3)).
6. Compute min(max(ToInteger(deleteCount),0),Result(3)–Result(5)).
7. Let k be 0.
8. If k equals Result(6), go to step 16.
9. Call ToString(Result(5)+k).
10. If this object has a property named by Result(9), go to step 11; but if this object has no property named by Result(9), then go to step 14.
11. Call ToString(k).
12. Call the [[Get]] method of this object with argument Result(9).
13. Call the [[Put]] method of A with arguments Result(11) and Result(12).
15. Go to step 8.
16. Call the [[Put]] method of A with arguments "length" and Result(6).
17. Compute the number of additional arguments item1, item2, etc.
18. If Result(17) is equal to Result(6), go to step 48.
19. If Result(17) is greater than Result(6), go to step 37.
20. Let k be Result(5).
21. If k is equal to (Result(3)–Result(6)), go to step 31.
22. Call ToString(k+Result(6)).
23. Call ToString(k+Result(17)).
24. If this object has a property named by Result(22), go to step 25; but if this object has no property named by Result(22), then go to step 28.
25. Call the [[Get]] method of this object with argument Result(22).
26. Call the [[Put]] method of this object with arguments Result(23) and Result(25).
27. Go to step 29.
28. Call the [[Delete]] method of this object with argument Result(23).
29. Increase \( k \) by 1.
30. Go to step 21.
31. Let \( k \) be Result(3).
32. If \( k \) is equal to (Result(3)–Result(6)+Result(17)), go to step 48.
33. Call ToString(\( k \)–1).
34. Call the [[Delete]] method of this object with argument Result(33).
35. Decrease \( k \) by 1.
36. Go to step 32.
37. Let \( k \) be (Result(3)–Result(6)).
38. If \( k \) is equal to Result(5), go to step 48.
39. Call ToString(\( k \)+Result(6)–1).
40. Call ToString(\( k \)+Result(17)–1).
41. If this object has a property named by Result(39), go to step 42; but if this object has no property named by Result(39), then go to step 45.
42. Call the [[Get]] method of this object with argument Result(39).
43. Call the [[Put]] method of this object with arguments Result(40) and Result(42).
44. Go to step 46.
45. Call the [[Delete]] method of this object with argument Result(40).
46. Decrease \( k \) by 1.
47. Go to step 38.
48. Let \( k \) be Result(5).
49. Get the next argument in the part of the argument list that starts with \texttt{item1}; if there are no more arguments, go to step 53.
50. Call the [[Put]] method of this object with arguments ToString(\( k \)) and Result(49).
51. Increase \( k \) by 1.
52. Go to step 49.
53. Call the [[Put]] method of this object with arguments \texttt{"length"} and (Result(3)–Result(6)+Result(17)).
54. Return \( A \).

The \texttt{length} property of the \texttt{splice} method is 2.

**NOTE**
The \texttt{splice} function is intentionally generic; it does not require that its \texttt{this} value be an Array object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the \texttt{splice} function can be applied successfully to a host object is implementation-dependent.

### 15.4.4.13 Array.prototype.unshift ( [ \texttt{item1} | , \texttt{item2} | , ... | ] )

The arguments are prepended to the start of the array, such that their order within the array is the same as the order in which they appear in the argument list.

When the \texttt{unshift} method is called with zero or more arguments \texttt{item1}, \texttt{item2}, etc., the following steps are taken:
1. Call the [[Get]] method of this object with argument \texttt{"length"}.
2. Call ToUint32(Result(1)).
3. Compute the number of arguments.
4. Let \( k \) be Result(2).
5. If \( k \) is zero, go to step 15.
6. Call ToString(\( k \)–1).
7. Call ToString(\( k \)+Result(3)–1).
8. If this object has a property named by Result(6), go to step 9; but if this object has no property named by Result(6), then go to step 12.
9. Call the [[Get]] method of this object with argument Result(6).
10. Call the `[[Put]]` method of this object with arguments `Result(7)` and `Result(9)`.
12. Call the `[[Delete]]` method of this object with argument `Result(7)`.
13. Decrease \( k \) by 1.
14. Go to step 5.
15. Let \( k \) be 0.
16. Get the next argument in the part of the argument list that starts with `item1`; if there are no more arguments, go to step 21.
17. Call `ToString(\( k \))`.
18. Call the `[[Put]]` method of this object with arguments `Result(17)` and `Result(16)`.
19. Increase \( k \) by 1.
20. Go to step 16.
21. Call the `[[Put]]` method of this object with arguments "length" and `(Result(2)+Result(3))`.
22. Return \((Result(2)+Result(3))\).

The `length` property of the `unshift` method is 1.

**NOTE**
The `unshift` 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. Whether the `unshift` function can be applied successfully to a host object is implementation-dependent.

---

**15.4.4.14** `Array.prototype.indexOf (searchElement [ , fromIndex ] )`

`indexOf` compares `searchElement` to the elements of the array, in ascending order, using strict equality, and if found at one or more positions, returns the index of the first such position; otherwise, `-1` is returned.

The optional second argument `fromIndex` defaults to 0 (i.e. the whole array is searched). If it is greater than or equal to the length of the array, `-1` is returned, i.e. the array will not be searched. If it is negative, it is used as the offset from the end of the array to compute `fromIndex`. If the computed index is less than 0, the whole array will be searched.

When the `indexOf` method is called with one or two arguments, the following steps are taken:

1. Let \( E \) be this object.
2. Call the `[[Get]]` method of \( E \) with the argument "length".
3. Call `ToUint32(Result(2))`.
4. If Result(3) is 0 go to step 18.
5. Call `ToInt32(fromIndex)` (if `fromIndex` is `undefined` this step produces 0).
6. Let \( n \) be Result(5).
7. If \( n \) is greater than or equal to Result(3) go to step 18.
8. If \( n \) is greater than or equal to 0, let \( k \) be \( n \), and go to step 11.
9. Let \( k \) be Result(3) - abs(n).
10. If \( k \) is less than 0, let \( k \) be 0.
11. Call `ToString(k)`.
12. Call the `[[Get]]` method of \( E \) with the argument Result(11).
13. Perform the comparison `SameValue(searchElement, Result(12))`.
14. If Result(13) is `false` go to step 16.
15. Return \( k \).
16. Increase \( k \) by 1.
17. If \( k \) is less than Result(3) go to step 11.
18. Return \(-1\).

**NOTE**
The `indexOf` 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. Whether the `indexOf` function can be applied successfully to a host object is implementation-dependent.
15.4.4.15 Array.prototype.lastIndexOf ( searchElement [ , fromIndex ] )

`lastIndexOf` compares `searchElement` to the elements of the array in descending order using strict equality, and if found at one or more positions, returns the index of the last such position; otherwise, `-1` is returned.

The optional second argument `fromIndex` defaults to the array's length (i.e. the whole array is searched). If it is greater than or equal to the length of the array, the whole array will be searched. If it is negative, it is used as the offset from the end of the array to compute `fromIndex`. If the computed index is less than 0, `-1` is returned.

When the `lastIndexOf` method is called with one or two arguments, the following steps are taken:

1. Let `E` be this object.
2. Call the `[[Get]]` method of `E` with the argument "length".
3. Call `ToUint32(Result(2))`.
4. If `Result(3)` is 0 go to step 18.
5. Call `ToInt32(fromIndex)` (if `fromIndex` is undefined this step produces the same values as `Result(3)`).
6. Let `n` be `Result(5)`.
7. If `n` is greater than or equal to `Result(3)`, let `n` be `Result(3) - 1`, and go to step 11.
8. If `n` is greater than or equal to 0, let `k` be `n`, and go to step 11.
9. Let `k` be `Result(3) - abs(n)`.
10. If `k` is less than 0 go to step 18.
11. Call `ToString(k)`.
12. Call the `[[Get]]` method of `E` with the argument `Result(11)`.
13. Perform the comparison `SameValue(searchElement, Result(12))`.
14. If `Result(13)` is false go to step 16.
15. Return `k`.
16. Decrease `k` by 1.
17. If `k` is greater than or equal to 0 go to step 11.
18. Return `-1`.

**NOTE**
The `lastIndexOf` 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. Whether the `lastIndexOf` function can be applied successfully to a host object is implementation-dependent.

15.4.4.16 Array.prototype.every ( callbackfn [ , thisArg ] )

callbackfn should be a function that accepts three arguments and returns the boolean value `true` or `false`. `every` calls the provided callback, as a function, once for each element present in the array, in ascending order, until it finds one where `callbackfn` returns `false`. If such an element is found, `every` immediately returns `false`. Otherwise, if `callbackfn` returned `true` for all elements, `every` will return `true`. `callbackfn` is called only for indexes of the array which have assigned values; it is not called for indexes which have been deleted or which have never been assigned values.

If a `thisArg` parameter is provided, it will be used as the `this` value for each invocation of the callback. If it is not provided, `undefined` is used instead.

`callbackfn` is called with three arguments: the value of the element, the index of the element, and the Array object being traversed.

`every` does not mutate the array on which it is called.

The range of elements processed by `every` is set before the first call to `callbackfn`. Elements which are appended to the array after the call to `every` begins will not be visited by `callbackfn`. If existing elements of the array are changed, their value as passed to `callbackfn` will be the value at the time `every` visits them; elements that are deleted are not visited. `every` acts like the "for all" quantifier in mathematics. In particular, for an empty array, it returns `true`.

When the `every` method is called with one or two arguments, the following steps are taken:

1. Let `E` be this object.
2. Call the [[Get]] method of $E$ with the argument "length".
3. Call ToUint32(Result(2)).
4. If Result(3) is 0 go to step 18.
5. If Type(callbackfn) is not Object, throw a TypeError exception.
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. Let $O$ be thisArg.
8. Let $k$ be 0.
9. Call ToString($k$).
10. If $E$ does not have a property named by Result(9), go to step 16.
11. Call the [[Get]] method of $E$ with argument Result(9).
12. Call the [[Call]] method of callbackfn with $O$ as the this value and arguments Result(11), $k$, and $E$.
13. Call ToBoolean(Result(12)).
14. If Result(13) is true go to step 16.
15. Return false.
16. Increase $k$ by 1.
17. If $k$ is less than Result(3) go to step 9.
18. Return true.

**NOTE**
The every 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. Whether the every function can be applied successfully to a host object is implementation-dependent.

### 15.4.4.17 Array.prototype.some (callbackfn [, thisArg])

`callbackfn` should be a function that accepts three arguments and returns the boolean value true or false. `some` calls the callback, as a function, once for each element present in the array, in ascending order, until it finds one where `callbackfn` returns true. If such an element is found, some immediately returns true. Otherwise, `some` returns false. `callbackfn` is called only for indexes of the array which have assigned values; it is not called for indexes which have been deleted or which have never been assigned values.

If a `thisArg` parameter is provided, it will be used as the this value for each invocation of the callback. If it is not provided, undefined is used instead.

`callbackfn` is called with three arguments: the value of the element, the index of the element, and the Array object being traversed.

`some` does not mutate the array on which it is called.

The range of elements processed by `some` is set before the first call to `callbackfn`. Elements that are appended to the array after the call to `some` begins will not be visited by `callbackfn`. If an existing, unvisited element of the array is changed by `callbackfn`, their value as passed to `callbackfn` will be the value at the time that `some` visits them; elements that are deleted are not visited.

When the `some` method is called with one or two arguments, the following steps are taken:

1. Let $E$ be this object.
2. Call the [[Get]] method of $E$ with the argument "length".
3. Call ToUint32(Result(2)).
4. If Result(3) is 0 go to step 18.
5. If Type(callbackfn) is not Object, throw a TypeError exception.
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. Let $O$ be thisArg.
8. Let $k$ be 0.
9. Call ToString($k$).
10. If $E$ does not have a property named by Result(9), go to step 16.
11. Call the [[Get]] method of $E$ with argument Result(9).
12. Call the [[Call]] method of callbackfn with $O$ as the this value and arguments Result(11), $k$, and $E$.
13. Call ToBoolean(Result(12)).
14. If Result(13) is false go to step 16.
15. Return true.
16. Increase k by 1.
17. If k is less than Result(3) go to step 9.
18. Return false.

NOTE
The some 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. Whether the some function can be applied successfully to a host object is implementation-dependent.

15.4.4.18 Array.prototype.forEach (callbackfn [ , thisArg ])
callbackfn should be a function that accepts three arguments. forEach calls the provided callback, as a function, once for each element present in the array, in ascending order. callbackfn is called only for indexes of the array which have assigned values; it is not called for indexes which have been deleted or which have never been assigned values.

If a thisArg parameter is provided, it will be used as the this value for each invocation of the callback. If it is not provided, undefined is used instead.

callbackfn is called with three arguments: the value of the element, the index of the element, and the Array object being traversed.

forEach does not mutate the array on which it is called.

The range of elements processed by forEach is set before the first call to callbackfn. Elements which are appended to the array after the call to forEach begins will not be visited by callbackfn. If existing elements of the array are changed, or deleted, their value as passed to callback will be the value at the time forEach visits them; elements that are deleted are not visited.

When the forEach method is called with one or two arguments, the following steps are taken:
1. Let E be this object.
2. Call the [[Get]] method of E with the argument "length".
3. Call ToUint32(Result(2)).
4. If Result(3) is 0 go to step 14.
5. If Type(callbackfn) is not Object, throw a TypeError exception.
6. If IsCallable(callbackfn) is false, throw a TypeError exception.
7. Let O be thisArg.
8. Let k be 0.
9. Call ToString(k).
10. If E does not have a property named by Result(9), go to step 13.
11. Call the [[Get]] method of E with argument Result(9).
12. Call the [[Call]] method of callbackfn with O as this value and arguments Result(11), k, and E.
13. Increase k by 1.
14. If k is less than Result(3) go to step 9.
15. Return.

NOTE
The forEach 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. Whether the forEach function can be applied successfully to a host object is implementation-dependent.

15.4.4.19 Array.prototype.map (callbackfn [ , thisArg ])
callbackfn should be a function that accepts three arguments. map calls the provided callback, as a function, once for each element in the array, in ascending order, and constructs a new array from the results. callbackfn is called only for indexes of the array which have assigned values; it is not called for indexes which have been deleted or which have never been assigned values.

If a thisArg parameter is provided, it will be used as the this value for each invocation of the callback. If it is not provided, undefined is used instead.
callbackfn is called with three arguments: the value of the element, the index of the element, and the Array object being traversed.

map does not mutate the array on which it is called.

The range of elements processed by map is set before the first call to callbackfn. Elements which are appended to the array after the call to map begins will not be visited by callbackfn. If existing elements of the array are changed, or deleted, their value as passed to callbackfn will be the value at the time map visits them; elements that are deleted are not visited.

When the map method is called with one or two arguments, the following steps are taken:

1. Let A be a new array created as if by the expression new Array() where Array is the standard built-in constructor with that name.
2. Let n be 0.
3. Let E be this object.
4. Call the [[Get]] method of E with the argument "length".
5. Call ToUint32(Result(4)).
6. If Result(5) is 0 go to step 20.
7. If Type(callbackfn) is not Object, throw a TypeError exception.
8. If IsCallable(callbackfn) is false, throw a TypeError exception.
9. Let O be thisArg.
10. Let k be 0.
11. Call ToString(k).
12. If E does not have a property named by Result(11), go to step 19.
13. Call the [[Get]] method of E with argument Result(11).
14. Call the [[Call]] method of callbackfn with O as the this value and arguments Result(13), k, and E.
15. Call ToString(n).
16. Call the [[Put]] method of A with the argument Result(14) and Result(15).
17. Increase n by 1.
18. Increase k by 1.
19. If k is less than Result(5) go to step 11.
20. Return A.

NOTE
The map 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. Whether the map function can be applied successfully to a host object is implementation-dependent.

15.4.4.20 Array.prototype.filter (callbackfn [, thisArg ])
callbackfn should be a function that accepts three arguments and returns the boolean value true or false. filter calls the provided callback, as a function, once for each element in the array, in ascending order, and constructs a new array of all the values for which callbackfn returns true. callbackfn is called only for indexes of the array which have assigned values; it is not called for indexes which have been deleted or which have never been assigned values.

If a thisArg parameter is provided, it will be used as the this value for each invocation of the callback. If it is not provided, undefined is used instead.

callbackfn is called with three arguments: the value of the element, the index of the element, and the Array object being traversed.

filter does not mutate the array on which it is called.

The range of elements processed by filter is set before the first call to callbackfn. Elements which are appended to the array after the call to filter begins will not be visited by callbackfn. If existing elements of the array are changed, or deleted, their value as passed to callbackfn will be the value at the time filter visits them; elements that are deleted are not visited.

When the filter method is called with one or two arguments, the following steps are taken:
1. Let $A$ be a new array created as if by the expression `new Array()` where `Array` is the standard built-in constructor with that name.
2. Let $n$ be 0.
3. Let $E$ be this object
4. Call the `[[Get]]` method of $E$ with the argument "$length".
5. Call `ToUint32(Result(4))`.
6. If `Result(5)` is 0 go to step 22.
7. If `Type(callbackfn)` is not `Object`, throw a `TypeError` exception.
8. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
9. Let $O$ this `thisArg`.
10. Let $k$ be 0.
11. Call `ToString(k)`.
12. If $E$ does not have a property named by `Result(11)`, go to step 20.
13. Call the `[[Get]]` method of $E$ with argument `Result(11)`.
14. Call the `[[Call]]` method of `callbackfn` with $O$ as the `this` value and arguments `Result(13)`, $k$, and $E$.
15. Call `ToBoolean(Result(14))`.
16. If `Result(15)` is `false` go to step 20.
17. Call `ToString(n)`.
18. Call the `[[Put]]` method of $A$ with the argument `Result(13)` and `Result(17)`.
19. Increase $n$ by 1.
20. Increase $k$ by 1.
21. If $k$ is less than `Result(5)` go to step 11.
22. Return $A$.

**NOTE**
The `filter` 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. Whether the `filter` function can be applied successfully to a host object is implementation-dependent.

15.4.4.2 `Array.prototype.reduce (callbackfn [, initialValue])`

`callbackfn` should be a function that takes four arguments, `reduce` calls the callback, as a function, once for each element present in the array, in ascending order.

`callbackfn` is called with four arguments: the previousValue (or value from the previous call to `callbackfn`), the currentValue (value of the current element), the currentIndex, and the Array object being traversed. The first time that callback is called, the previousValue and currentValue can be one of two values. If an `initialValue` was provided in the call to `reduce`, then previousValue will be equal to `initialValue` and currentValue will be equal to the first value in the array. If no `initialValue` was provided, then previousValue will be equal to the first value in the array and currentValue will be equal to the second.

`reduce` does not mutate the array on which it is called.

The range of elements processed by `reduce` is set before the first call to `callbackfn`. Elements that are appended to the array after the call to `reduce` begins will not be visited by `callbackfn`. If an existing, unvisited element is changed by `callbackfn`, their value as passed to `callbackfn` will be the value at the time `reduce` visits them; elements that are deleted are not visited.

When the `reduce` method is called with one or two arguments, the following steps are taken:

1. Let $E$ be this object.
2. Call the `[[Get]]` method on $E$ with argument "$length".
3. Call `ToUint32(Result(2))`.
4. If `Type(callbackfn)` is not `Object`, throw a `TypeError` exception.
5. If `IsCallable(callbackfn)` is `false`, throw a `TypeError` exception.
6. If `Result(3)` is 0 and `initialValue` is not supplied throw a `TypeError` exception.
7. Let $k$ be 0.
8. If `initialValue` is supplied let $P$ be `initialValue` and go to step 17.
9. Call `ToString(k)`.
10. If $E$ does not have a property named by `Result(9)`, go to step 14.
11. Call the \([\text{Get}]\) method on \(E\) with the argument \(\text{Result}(9)\).
12. Increase \(k\) by 1.
13. Let \(P\) be \(\text{Result}(11)\) and go to step 17.
14. Increase \(k\) by 1.
15. If \(k < \text{Result}(3)\) go to step 9.
16. Throw a \(\text{TypeError}\) exception.
17. Call \(\text{ToString}(k)\).
18. If \(E\) does not have a property named by \(\text{Result}(17)\), go to step 22.
19. Call the \([\text{Get}]\) method of \(E\) with the argument \(\text{Result}(17)\).
20. Call the \([\text{Call}]\) method on \(\text{callbackfn}\) with \(null\) as \(\text{this}\) value and arguments \(P\), \(\text{Result}(19)\), \(k\), \(E\).
21. Let \(P\) be \(\text{Result}(20)\).
22. Increase \(k\) by 1.
23. If \(k < \text{Result}(3)\) go to step 17.
24. Return \(P\).

\(\text{NOTE}\)
The \(\text{reduce}\) function is intentionally generic; it does not require that its \(\text{this}\) value be an \(\text{Array}\) object. Therefore it can be transferred to other kinds of objects for use as a method. Whether the \(\text{reduce}\) function can be applied successfully to a host object is implementation-dependent.

### 15.4.4.22 \text{Array.prototype.reduceRight( callbackfn[,initialValue])}

\(\text{callbackfn}\) should be a function that takes four arguments. \(\text{reduceRight}\) calls the callback, as a function, once for each element present in the array, in descending order.

\(\text{callbackfn}\) is called with four arguments: \(\text{previousValue}\) (or value from the previous call to \(\text{callbackfn}\)), \(\text{currentValue}\) (value of the current element), \(\text{currentIndex}\), and the Array object being traversed. The first time the function is called, the \(\text{previousValue}\) and \(\text{currentValue}\) can be one of two values. If an \(\text{initialValue}\) was provided in the call to \(\text{reduceRight}\), then \(\text{previousValue}\) will be equal to \(\text{initialValue}\) and \(\text{currentValue}\) will be equal to the last value in the array. If no \(\text{initialValue}\) was provided, then \(\text{previousValue}\) will be equal to the last value in the array and \(\text{currentValue}\) will be equal to the second-to-last value.

\(\text{reduceRight}\) does not mutate the array on which it is called.

The range of elements processed by \(\text{reduceRight}\) is set before the first call to \(\text{callbackfn}\). Elements that are appended to the array after the call to \(\text{reduceRight}\) begins will not be visited by \(\text{callbackfn}\). If an existing, unvisited element is changed by \(\text{callbackfn}\), their value as passed to \(\text{callbackfn}\) will be the value at the time \(\text{reduceRight}\) visits them; elements that are deleted are not visited.

When the \(\text{reduceRight}\) method is called with one or two arguments, the following steps are taken:

1. Let \(E\) be this object.
2. Call the \([\text{Get}]\) method on \(E\) with argument "length".
3. Call ToUint32(\(\text{Result}(2)\)).
4. If Type(\(\text{callbackfn}\)) is not \text{Object} throw a \(\text{TypeError}\) exception.
5. If IsCallable(\(\text{callbackfn}\)) is \text{false}, throw a \(\text{TypeError}\) exception.
6. If \(\text{Result}(3)\) is 0 and \(\text{initialValue}\) is not supplied throw a \(\text{TypeError}\) exception.
7. Let \(k\) be \(\text{Result}(3) - 1\).
8. If \(\text{initialValue}\) is supplied let \(P\) be \(\text{initialValue}\) and go to step 17.
9. Call ToString(\(k\)).
10. If \(E\) does not have a property named by \(\text{Result}(9)\), go to step 14.
11. Call the \([\text{Get}]\) method on \(E\) with the argument \(\text{Result}(9)\).
12. Decrease \(k\) by 1.
13. Let \(P\) be \(\text{Result}(11)\) and go to step 17.
14. Decrease \(k\) by 1.
15. If \(k\) is greater than or equal to 0 go to step 9.
16. Throw a \(\text{TypeError}\) exception.
17. Call ToString(\(k\)).
18. If \(E\) does not have a property named by \(\text{Result}(17)\), go to step 22.
19. Call the `[[Get]]` method of `E` with the argument `Result(17)`,
20. Call the `[[Call]]` method on `callbackfn` with `null` as the this value and arguments `P`, `Result(19)`, `k`, `E`.
21. Let `P` be `Result(20)`.
22. Decrease `k` by 1.
23. If `k` is greater than or equal to 0 go to step 17.

**NOTE**
The `reduceRight` 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. Whether the `reduceRight` function can be applied successfully to a host object is implementation-dependent.

### 15.4.5 Properties of Array Instances

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

#### 15.4.5.1 `[[ThrowablePut]] (P, V, Throw)

Array objects use a variation of the `[[ThrowablePut]]` method used for other native ECMAScript objects (8.6.2.10).

Assume `A` is an Array object, `P` is a string, and `Throw` is a boolean flag.

When the `[[ThrowablePut]]` method of `A` is called with property `P`, value `V`, and Boolean flag `Throw`, the following steps are taken:

1. Call the `[[CanPut]]` method of `A` with name `P`.
2. If Result(1) is false, then
   a. If `Throw` is `true`, throw a `TypeError` exception.
   b. Else 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`.
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 `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. If `Result(12)` is not equal to `ToNumber(V)`, throw a `RangeError` exception.
14. 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 an own property (a non-inherited property) named `ToString(k)`, then delete that property.
15. Set the value of property `P` of `A` to `Result(12)`.
16. Return.

#### 15.4.5.2 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 attributes `{{[Enumerable]: false, [Configurable]: false}}`.

### 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)`. If `value` is not supplied, the empty string "" is returned.

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15.5.2 The String Constructor

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

15.5.2.1 `new 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` (15.5.3.1).

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

The `[[PrimitiveValue]]` property of the newly constructed object is set to `ToString(value)`, or to the empty string if `value` is not supplied.

15.5.3 Properties of the String Constructor

The value of the internal `[[Prototype]]` property of the String constructor is the Function prototype object (15.3.4).

Besides the internal properties and the `length` property (whose value is 1), the String constructor has the following properties:

15.5.3.1 `String.prototype`

The initial value of `String.prototype` is the String prototype object (15.5.4).

This property has the attributes `{ `[[Writable]]`: false, `[[Enumerable]]`: false, `[[Configurable]]`: false }.

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 (9.7)` and regarding the resulting 16-bit integer as the code point value of a character. If no arguments are supplied, the result is the empty string.

The `length` property of the `fromCharCode` function is 1.

15.5.4 Properties of the String Prototype Object

The String prototype object is itself a String object (its `[[Class]]` is "String") whose value is an empty string.

The value of the internal `[[Prototype]]` property of the String prototype object is the Object prototype object (15.2.3.1).

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 throws a `TypeError` exception 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 throws a `TypeError` exception 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 the string resulting from converting this object to a 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.

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If \( pos \) is a value of Number type that is an integer, then the result of \( x.charAt(pos) \) is equal to the result of \( x.substring(pos, pos+1) \).

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**

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 code point value of the character at position \( pos \) in the string resulting from converting this object to a 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, whose value is the code point value of the character at position Result(2) in the string Result(1), 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**

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.concat \([ \text{string1, string2, ...} ]\)

When the \( concat \) method is called with zero or more arguments \( \text{string1, string2, etc.} \), it returns a string consisting of the characters of this object (converted to a string) followed by the characters of each of \( \text{string1, string2, etc.} \) (where each argument is converted to a string). The result is a string value, not a String object. The following steps are taken:

1. Call \( ToString \), giving it the \( this \) value as its argument.
2. Let \( R \) be Result(1).
3. Get the next argument in the argument list; if there are no more arguments, go to step 7.
4. Call \( ToString(Result(3)) \).
5. Let \( R \) be the string value consisting of the characters in the previous value of \( R \) followed by the characters Result(4).
6. Go to step 3.
7. Return \( R \).

The **length** property of the \( concat \) method is 1.

**NOTE**

The \( concat \) 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.indexOf \((\text{searchString, position})\)

If \( \text{searchString} \) appears as a substring of the result of converting this object to a string, at one or more positions that are greater than or equal to \( \text{position} \), then the index of the smallest such position is
returned; otherwise, -1 is returned. If position is undefined, 0 is assumed, so as to search all of the string.

The indexOf method takes two arguments, searchString and position, and performs the following steps:

1. Call ToString, giving it the this value as its argument.
2. Call ToString(searchString).
3. Call ToInteger(position). (If position is undefined, 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).

The length property of the indexOf method is 1.

NOTE
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.

15.5.4.8 String.prototype.lastIndexOf (searchString, position)
If searchString appears as a substring of the result of converting this object to a string at one or more positions that are smaller than or equal to position, then the index of the greatest such position is returned; otherwise, -1 is returned. If position is undefined, the length of the string value is assumed, so as to search all of the string.

The lastIndexOf method takes two arguments, searchString and position, and performs the following steps:

1. Call ToString, giving it the this value as its argument.
2. Call ToString(searchString).
3. Call ToNumber(position). (If position is undefined, this step produces the value NaN).
4. If Result(3) is NaN, use +Infinity; 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 nonnegative 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).

The length property of the lastIndexOf method is 1.

NOTE
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.

15.5.4.9 String.prototype.localeCompare (that)
When the localeCompare method is called with one argument that, it returns a number other than NaN that represents the result of a locale-sensitive string comparison of this object (converted to a string) with that (converted to a string). The two strings are compared in an implementation-defined fashion. The result is intended to order strings in the sort order specified by the system default locale, and will be negative, zero, or positive, depending on whether this comes before that in the sort order, the strings are equal, or this comes after that in the sort order, respectively.

The localeCompare method, if considered as a function of two arguments this and that, is a consistent comparison function (as defined in 15.4.4.11) on the set of all strings. Furthermore,
localeCompare returns 0 or −0 when comparing two strings that are considered canonically equivalent by the Unicode standard.

The actual return values are left implementation-defined to permit implementers to encode additional information in the result value, but the function is required to define a total ordering on all strings and to return 0 when comparing two strings that are considered canonically equivalent by the Unicode standard.

NOTE 1
The `localeCompare` method itself is not directly suitable as an argument to `Array.prototype.sort` because the latter requires a function of two arguments.

NOTE 2
This function is intended to rely on whatever language-sensitive comparison functionality is available to the ECMAScript environment from the host environment, and to compare according to the rules of the host environment’s current locale. It is strongly recommended that this function treat strings that are canonically equivalent according to the Unicode standard as identical (in other words, compare the strings as if they had both been converted to Normalised Form C or D first). It is also recommended that this function not honour Unicode compatibility equivalences or decompositions.

If no language-sensitive comparison at all is available from the host environment, this function may perform a bitwise comparison.

NOTE 3
The `localeCompare` 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.

NOTE 4
The second parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

15.5.4.10 `String.prototype.match (regexp)`

If `regexp` is not an object whose [[Class]] property is “RegExp”, it is replaced with the result of the expression `new RegExp(regexp)`. Let `string` denote the result of converting the this value to a string. Then do one of the following:

If `regexp.global` is false: Return the result obtained by invoking `RegExp.prototype.exec` (see 15.10.6.2) on `regexp` with `string` as parameter.

If `regexp.global` is true: Set the `regexp.lastIndex` property to 0 and invoke `RegExp.prototype.exec` repeatedly until there is no match. If there is a match with an empty string (in other words, if the value of `regexp.lastIndex` is left unchanged), increment `regexp.lastIndex` by 1. Let `n` be the number of matches. If `n`=0, then the value returned is `null`; otherwise, the value returned is an array with the `length` property set to `n` and properties 0 through `n`−1 corresponding to the first elements of the results of all matching invocations of `RegExp.prototype.exec`

NOTE
The `match` 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.replace (searchValue, replaceValue)`

Let `string` denote the result of converting the this value to a string.

If `searchValue` is a regular expression (an object whose [[Class]] property is “RegExp”), do the following: If `searchValue.global` is false, then search `string` for the first match of the regular expression `searchValue`. If `searchValue.global` is true, then search `string` for all matches of the regular expression `searchValue`. Do the search in the same manner as in `String.prototype.match`, including the update of `searchValue.lastIndex`. Let `m` be the number of left capturing parentheses in `searchValue` (NcapturingParens as specified in 15.10.2.1).

If `searchValue` is not a regular expression, let `searchString` be `ToString(searchValue)` and search `string` for the first occurrence of `searchString`. Let `m` be 0.
If replaceValue is a function, then for each matched substring, call the function with the following \( m + 3 \) arguments. Argument 1 is the substring that matched. If searchValue is a regular expression, the next \( m \) arguments are all of the captures in the MatchResult (see 15.10.2.1). Argument \( m + 2 \) is the offset within string where the match occurred, and argument \( m + 3 \) is string. The result is a string value derived from the original input by replacing each matched substring with the corresponding return value of the function call, converted to a string if need be.

Otherwise, let newstring denote the result of converting replaceValue to a string. The result is a string value derived from the original input string by replacing each matched substring with a string derived from newstring by replacing characters in newstring by replacement text as specified in the following table. These replacements are done left-to-right, and, once such a replacement is performed, the new replacement text is not subject to further replacements. For example, "$1,$2".replace(/(\$\1\d)/g, "$$1-$1$2") returns "$1-$11,$1-$22". A $ in newstring that does not match any of the forms below is left as is.

<table>
<thead>
<tr>
<th>Characters</th>
<th>Replacement text</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\n$</td>
<td>The matched substring</td>
</tr>
<tr>
<td>$\n$</td>
<td>The portion of string that precedes the matched substring</td>
</tr>
<tr>
<td>$\n$</td>
<td>The portion of string that follows the matched substring</td>
</tr>
<tr>
<td>$n$</td>
<td>The ( n )th capture, where ( n ) is a single digit 1-9 and $n$ is not followed by a decimal digit. If ( n&gt;m ) and the ( n )th capture is undefined, use the empty string instead. If ( n&gt;m ), the result is implementation-defined.</td>
</tr>
<tr>
<td>$nn$</td>
<td>The ( nn )th capture, where ( nn ) is a two-digit decimal number 01-99. If ( nn&gt;m ) and the ( nn )th capture is undefined, use the empty string instead. If ( nn&gt;m ), the result is implementation-defined.</td>
</tr>
</tbody>
</table>

NOTE
The replace 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.search (regexp)
If regexp is not an object whose [[Class]] property is "RegExp", it is replaced with the result of the expression `new RegExp(regexp)`. Let string denote the result of converting the this value to a string.

The value string is searched from its beginning for an occurrence of the regular expression pattern regexp. The result is a number indicating the offset within the string where the pattern matched, or \(-1\) if there was no match.

**NOTE 1**
This method ignores the lastIndex and global properties of regexp. The lastIndex property of regexp is left unchanged.

**NOTE 2**
The search 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.

15.5.4.13 String.prototype.slice (start, end)
The slice method takes two arguments, start and end, and returns a substring of the result of converting this object to a string, starting from character position start and running to, but not including, character position end (or through the end of the string if end is undefined). If start is negative, it is treated as \( (sourceLength+start) \) where sourceLength is the length of the string. If end is negative, it is not treated as \( (sourceLength+end) \) where sourceLength is the length of the string. The result is a string value, not a String object. The following steps are taken:

1. Call ToString, giving it the this value as its argument.

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2. Compute the number of characters in Result(1).
3. Call ToInteger(start).
4. If end is undefined, use Result(2); else use ToInteger(end).
5. If Result(3) is negative, use max(Result(2)+Result(3),0); else use min(Result(3),Result(2)).
6. If Result(4) is negative, use max(Result(2)+Result(4),0); else use min(Result(4),Result(2)).
7. Compute max(Result(6)–Result(5),0).
8. Return a string containing Result(7) consecutive characters from Result(1) beginning with the character at position Result(5).

The length property of the slice method is 2.

NOTE
The slice 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.

15.5.4.14 String.prototype.split (separator, limit)

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 separator; these occurrences are not part of any substring in the returned array, but serve to divide up the string value. The value of separator may be a string of any length or it may be a RegExp object (i.e., an object whose [[Class]] property is "RegExp"; see 15.10).

The value of separator may be an empty string, an empty regular expression, or a regular expression that can match an empty string. In this case, separator does not match the empty substring at the beginning or end of the input string, nor does it match the empty substring at the end of the previous separator match. (For example, if 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 separator is a regular expression, only the first match at a given position of the this string is considered, even if backtracking could yield a non-empty-substring match at that position. (For example, "ab".split(/a*?/) evaluates to the array ["a","b"], while "ab".split(/a*/) evaluates to the array ["","b"].)

If the this object is (or converts to) the empty string, the result depends on whether separator can match the empty string. If it can, the result array contains no elements. Otherwise, the result array contains one element, which is the empty string.

If separator is a regular expression that contains capturing parentheses, then each time separator is matched the results (including any undefined results) of the capturing parentheses are spliced into the output array. (For example, "AC>Bold/End<Code>".split(/</(\{[^<>]+\})*/g) evaluates to the array ["A", undefined, "B", "Bold", "/", "B", "and", undefined, "Code", "Code", "/", "Code", "]"].)

If separator is undefined, then the result array contains just one string, which is the this value (converted to a string). If limit is not undefined, then the output array is truncated so that it contains no more than limit elements.

When the split method is called, the following steps are taken:
1. Let S = ToString(this).
2. Let A be a new array created as if by the expression new Array() where Array is the standard built-in constructor with that name.
3. If limit is undefined, let lim = 2^{25}–1; else let lim = ToUint32(limit).
4. Let s be the number of characters in S.
5. Let p = 0.
6. If separator is a RegExp object (its [[Class]] is "RegExp"), let R = separator; otherwise let R = ToString(separator).
7. If lim = 0, return A.
8. If separator is undefined, go to step 33.
9. If p = 0, go to step 31.
10. Let q = p.

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11. If \( q = s \), go to step 28.
12. Call `SplitMatch(R, S, q)` and let \( z \) be its MatchResult result.
13. If \( z \) is failure, go to step 26.
14. \( z \) must be a State. Let \( e \) be \( z \)'s endIndex and let \( cap \) be \( z \)'s captures array.
15. If \( e = p \), go to step 26.
16. Let \( T \) be a string value equal to the substring of \( S \) consisting of the characters at positions \( p \) (inclusive) through \( q \) (exclusive).
17. Call the \([\text{Put}]\) method of \( A \) with arguments \( A \).length and \( T \).
18. If \( A \).length = lim, return \( A \).
19. Let \( p = e \).
20. Let \( i = 0 \).
21. If \( i \) is equal to the number of elements in \( cap \), go to step 10.
22. Let \( i = i + 1 \).
23. Call the \([\text{Put}]\) method of \( A \) with arguments \( A \).length and \( cap[i] \).
24. If \( A \).length = lim, return \( A \).
25. Go to step 21.
26. Let \( q = q+1 \).
27. Go to step 11.
28. Let \( T \) be a string value equal to the substring of \( S \) consisting of the characters at positions \( p \) (inclusive) through \( s \) (exclusive).
29. Call the \([\text{Put}]\) method of \( A \) with arguments \( A \).length and \( T \).
30. Return \( A \).
31. Call `SplitMatch(R, S, 0)` and let \( z \) be its MatchResult result.
32. If \( z \) is not failure, return \( A \).
33. Call the \([\text{Put}]\) method of \( A \) with arguments "0" and \( S \).
34. Return \( A \).

The abstract operation `SplitMatch` takes three parameters, a string \( S \), an integer \( q \), and a string or RegExp \( R \), and performs the following in order to return a MatchResult (see 15.10.2.1):

1. If \( R \) is a RegExp object (its \([\text{Class}]\) is "RegExp"), go to step 8.
2. \( R \) must be a string. Let \( r \) be the number of characters in \( R \).
3. Let \( s \) be the number of characters in \( S \).
4. If \( q+r > s \) then return the MatchResult failure.
5. Let \( p \) be an integer between 0 (inclusive) and \( r \) (exclusive) such that the character at position \( q+i \) of \( S \) is different from the character at position \( i \) of \( R \), then return failure.
6. Let \( cap \) be an empty array of captures (see 15.10.2.1).
7. Return the State \((q+r, cap)\). (see 15.10.2.1)
8. Call the \([\text{Match}]\) method of \( R \) giving it the arguments \( S \) and \( q \), and return the MatchResult result.

The `length` property of the `split` method is 2.

**NOTE 1**
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.

**NOTE 2**
The `split` method ignores the value of separator `global` for separators that are RegExp objects.

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

The `substring` method takes two arguments, `start` and `end`, and returns a substring of the result of converting this object to a string, starting from character position `start` and running to, but not including, character position `end` of the string (or through the end of the string if `end` is `undefined`).

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.

The following steps are taken:

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1. Call ToString, giving it the this value as its argument.
2. Compute the number of characters in Result(1).
3. Call ToInteger(start).
4. If end is undefined, use Result(2); else use ToInteger(end).
5. Compute min(max(Result(3), 0), Result(2)).
6. Compute min(max(Result(4), 0), Result(2)).
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) - 1, in ascending order.

The length property of the substring method is 2.

NOTE
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.

15.5.4.16 String.prototype.toLowerCase ()
If this object is not already a string, it is converted to a string. The characters in that string are converted one by one to lower case. The result is a string value, not a String object.

The characters are converted one by one. The result of each conversion is the original character, unless that character has a Unicode lowercase equivalent, in which case the lowercase equivalent is used instead.

NOTE 1
The result should be derived according to the case mappings in the Unicode character database (this explicitly includes not only the UnicodeData.txt file, but also the SpecialCasings.txt file that accompanies it in Unicode 2.1.8 and later).

NOTE 2
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.

15.5.4.17 String.prototype.toLocaleLowerCase ()
This function works exactly the same as toLowerCase except that its result is intended to yield the correct result for the host environment’s current locale, rather than a locale-independent result. There will only be a difference in the few cases (such as Turkish) where the rules for that language conflict with the regular Unicode case mappings.

NOTE 1
The toLocaleLowerCase 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.

NOTE 2
The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

15.5.4.18 String.prototype.toUpperCase ()
This function behaves in exactly the same way as String.prototype.toLowerCase, except that characters are mapped to their uppercase equivalents as specified in the Unicode Character Database.

NOTE 1
Because both toUpperCase and toLowerCase have context-sensitive behaviour, the functions are not symmetrical. In other words, s.toUpperCase().toLowerCase() is not necessarily equal to s.toLowerCase().

NOTE 2
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.

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15.5.19 `String.prototype.toLocaleUpperCase()`

This function works exactly the same as `toUpperCase` except that its result is intended to yield the correct result for the host environment’s current locale, rather than a locale-independent result. There will only be a difference in the few cases (such as Turkish) where the rules for that language conflict with the regular Unicode case mappings.

**NOTE 1**
The `toLocaleUpperCase` 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.

**NOTE 2**
The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

15.5.20 `String.prototype.trim()`

If this object is not already a string, it is converted to a string. The result is a copy of the string with both leading and trailing white space removed. The definition of white space is the union of `WhiteSpace` and `LineTerminator`. The result is a string value, not a String object.

**NOTE**
The `trim` 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.

15.5.21 `String.prototype.toJSON(key)`

When the `toJSON` method is called with argument `key`, the following steps are taken:

1. Let `O` be this object.
2. Call the `[[Get]]` method of `O` with argument "valueOf".
3. If `IsCallable(Result(2))` is `false`, go to step 6.
4. Call the `[[Call]]` method of `Result(2)` with `O` as the `this` value and an empty argument list.
5. If `Result(4)` is a primitive value, return `Result(4)`.
6. Throw a `TypeError` exception.

**NOTE**
The `toJSON` 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.

An object is free to use the argument `key` that is passed in to filter its stringification.

15.5.5 Properties of String Instances

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

The `[[PrimitiveValue]]` 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. It has the attributes `{ [[Writable]]: `false`, [[Enumerable]]: `false`, [[Configurable]]: `false` }.

15.5.5.2 `[[GetOwnProperty]](P)`

String objects use a variation of the `[[GetOwnProperty]]` method used for other native ECMAScript objects (8.6.2.8).

Assume `S` is a String object and `P` is a string.

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

1. Call the default `[[GetOwnProperty]]` method (8.6.2.8) with `S` as the `this` value and argument `P`.
2. If `Result(1)` is not `undefined` return `Result(1)`.
3. If `P` is not an array index (15.4), return `undefined`.
4. Call `ToString`, giving `S` as its argument.
5. Call ToInteger(P).
6. Compute the number of characters in Result(4).
7. If Result(5) is less than 0 or is not less than Result(6), return undefined.
8. Create a string of length 1, containing one character from Result(4), namely the character at position Result(5), where the first (leftmost) character in Result(4) is considered to be at position 0, the next one at position 1, and so on.
9. Return a Property Descriptor { [[Value]]: Result(8), [[Enumerable]]: false, [[Writable]]: false, [[Configurable]]: false }

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).

15.6.2 The Boolean Constructor

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

15.6.2.1 new 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 (15.6.3.1).

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

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

The [[Extensible]] property of the newly constructed object is set to true.

15.6.3 Properties of the Boolean Constructor

The value of the internal [[Prototype]] property of the Boolean constructor is the Function prototype object (15.3.4).

Besides the internal properties and the length property (whose value is 1), the Boolean constructor has the following property:

15.6.3.1 Boolean.prototype

The initial value of Boolean.prototype is the Boolean prototype object (15.6.4).

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.6.4 Properties of the Boolean Prototype Object

The Boolean prototype object is itself a Boolean object (its [[Class]] is "Boolean") whose value is false.

The value of the internal [[Prototype]] property of the Boolean prototype object is the Object prototype object (15.2.3.1).

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; a TypeError exception is thrown if the this value is not an object for which the value of the internal [[Class]] property is "Boolean". Also, the phrase “this boolean value” refers to the boolean value represented by this Boolean object, that is, the value of the internal [[PrimitiveValue]] 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 the string "false" is returned.
The `toString` function is not generic; it throws a `TypeError` exception 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 throws a `TypeError` exception if its `this` value is not a Boolean object. Therefore, it cannot be transferred to other kinds of objects for use as a method.

15.6.4.4 `Boolean.prototype.toJSON(key)`

When the `toJSON` method is called with argument `key`, the following steps are taken:

1. Let `O` be this object.
2. Call the `[[Get]]` method of `O` with argument "valueOf".
3. If IsCallable(Result(2)) is `false`, go to step 6
4. Call the `[[Call]]` method of Result(2) with `O` as the `this` value and an empty argument list.
5. If Result(4) is a primitive value, return Result(4).
6. Throw a `TypeError` exception.

**NOTE**
The `toJSON` function is intentionally generic; it does not require that its `this` value be a Boolean object. Therefore, it can be transferred to other kinds of objects for use as a method.

An object is free to use the argument 'key' that is passed in to filter its stringification.

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)` if `value` was supplied, else returns `+0`.

15.7.2 The Number Constructor

When `Number` is called as part of a `new` expression it is a constructor: it initialises the newly created object.

15.7.2.1 `new 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` (15.7.3.1).

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

The `[[PrimitiveValue]]` property of the newly constructed object is set to `ToNumber(value)` if `value` was supplied, else to `+0`.

The `[[Extensible]]` property of the newly constructed object is set to `true`.

15.7.3 Properties of the Number Constructor

The value of the internal `[[Prototype]]` property of the Number constructor is the Function prototype object (15.3.4).

Besides the internal properties and the `length` property (whose value is 1), the Number constructor has the following property:

15.7.3.1 `Number.prototype`

The initial value of `Number.prototype` is the Number prototype object (15.7.4).

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.
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 1.7976931348623157 \times 10^{308}.

This property has the attributes { [Writable]: false, [Enumerable]: false, [Configurable]: false }.

15.7.3.3 Number.MIN_VALUE
The value of Number.MIN_VALUE is the smallest positive value of the number type, which is approximately 5 \times 10^{-324}.

This property has the attributes { [Writable]: false, [Enumerable]: false, [Configurable]: false }.

15.7.3.4 Number.NaN
The value of Number.NaN is NaN.

This property has the attributes { [Writable]: false, [Enumerable]: false, [Configurable]: false }.

15.7.3.5 Number.NEGATIVE_INFINITY
The value of Number.NEGATIVE_INFINITY is -\infty.

This property has the attributes { [Writable]: false, [Enumerable]: false, [Configurable]: false }.

15.7.3.6 Number.POSITIVE_INFINITY
The value of Number.POSITIVE_INFINITY is +\infty.

This property has the attributes { [Writable]: false, [Enumerable]: false, [Configurable]: false }.

15.7.4 Properties of the Number Prototype Object
The Number prototype object is itself a Number object (its [Class] is "Number") whose value is +0.

The value of the internal [[Prototype]] property of the Number prototype object is the Object prototype object (15.2.3.1).

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; a TypeError exception is thrown if the this value is not an object for which the value of the internal [[Class]] property is "Number". Also, the phrase “this number value” refers to the number value represented by this Number object, that is, the value of the internal [[PrimitiveValue]] 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 (radix)
If radix is the number 10 or undefined, then this number value is given as an argument to the ToString operator; the resulting string value is returned.

If radix is an integer from 2 to 36, but not 10, the result is a string, the choice of which is implementation-dependent.

The toString function is not generic; it throws a TypeError exception 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.toLocaleString()
Produces a string value that represents the value of the Number formatted according to the conventions of the host environment’s current locale. This function is implementation-dependent, and it is permissible, but not encouraged, for it to return the same thing as toString.

NOTE
The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

15.7.4.4 Number.prototype.valueOf ( )
Returns this number value.

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The `valueOf` function is not generic; it throws a `TypeError` exception if its this value is not a Number object. Therefore, it cannot be transferred to other kinds of objects for use as a method.

15.7.4.5 `Number.prototype.toFixed (fractionDigits)`

Return a string containing the number represented in fixed-point notation with `fractionDigits` digits after the decimal point. If `fractionDigits` is `undefined`, 0 is assumed. Specifically, perform the following steps:

1. Let `f` be `ToInteger(fractionDigits)`. (If `fractionDigits` is `undefined`, this step produces the value 0).
2. If `f < 0` or `f > 20`, throw a `RangeError` exception.
3. Let `s` be this number value.
4. If `s` is `NaN`, return the string "NaN".
5. Let `x` be the empty string.
6. If `x >= 0`, go to step 9.
7. Let `s` be "-".
8. Let `x = -x`.
9. If `x >= 10^21`, let `m = ToString(x)` and go to step 20.
10. Let `n` be an integer for which the exact mathematical value of `n * 10^f - x` is as close to zero as possible. If there are two such `n`, pick the larger `n`.
11. If `n = 0`, let `m` be the string "0". Otherwise, let `m` be the string consisting of the digits of the decimal representation of `n` (in order, with no leading zeroes).
12. If `f = 0`, go to step 20.
13. Let `k` be the number of characters in `m`.
14. If `k > f`, go to step 18.
15. Let `z` be the string consisting of `f+1-k` occurrences of the character '0'.
16. Let `m` be the concatenation of strings `z` and `m`.
17. Let `k = f + 1`.
18. Let `a` be the first `k-f` characters of `m`, and let `b` be the remaining `f` characters of `m`.
19. Let `m` be the concatenation of the three strings `a`, " ", and `b`.
20. Return the concatenation of the strings `s` and `m`.

The `length` property of the `toFixed` method is 1.

If the `toFixed` method is called with more than one argument, then the behaviour is undefined (see clause 15).

An implementation is permitted to extend the behaviour of `toFixed` for values of `fractionDigits` less than 0 or greater than 20. In this case `toFixed` would not necessarily throw `RangeError` for such values.

**NOTE**

The output of `toFixed` may be more precise than `toString` for some values because `toString` only prints enough significant digits to distinguish the number from adjacent number values. For example, `(1000000000000000128).toString()` returns "1000000000000000100", while `(1000000000000000128).toFixed(0)` returns "1000000000000000128".

15.7.4.6 `Number.prototype.toExponential (fractionDigits)`

Return a string containing the number represented in exponential notation with one digit before the significand’s decimal point and `fractionDigits` digits after the significand’s decimal point. If `fractionDigits` is `undefined`, include as many significand digits as necessary to uniquely specify the number (just like in `toString` except that in this case the number is always output in exponential notation). Specifically, perform the following steps:

1. Let `x` be this number value.
2. Let `f` be `ToInteger(fractionDigits)`.
3. If `x` is `NaN`, return the string "NaN".
4. Let `x` be the empty string.
5. If `x >= 0`, go to step 8.
6. Let `s` be "-".
7. Let `x = -x`.

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8. If \( x = \infty \), let \( m = "\text{Infinity}" \) and go to step 30.
9. If \( \text{fractionDigits} \) is \( \text{undefined} \), go to step 14.
10. If \( f < 0 \) or \( f > 20 \), throw a \text{RangeError} \) exception.
11. If \( x = 0 \), go to step 16.
12. Let \( e \) and \( n \) be integers such that \( 10^f \leq n < 10^{f+1} \) and for which the exact mathematical value of \( n \times 10^{-f} - x \) is as close to zero as possible. If there are two such sets of \( e \) and \( n \), pick the \( e \) and \( n \) for which \( n \times 10^{-f} \) is larger.
14. If \( s \neq 0 \), go to step 19.
15. Let \( f = 0 \).
16. Let \( m \) be the string consisting of \( f+1 \) occurrences of the character ‘0’.
17. Let \( e = 0 \).
18. Go to step 21.
19. Let \( e, n, \) and \( f \) be integers such that \( f \geq 0, 10^f \leq n < 10^{f+1} \), the number value for \( n \times 10^{-f} \) is \( x \), and \( f \) is as small as possible. Note that the decimal representation of \( n \) has \( f+1 \) digits, \( n \) is not divisible by 10, and the least significant digit of \( n \) is not necessarily uniquely determined by these criteria.
20. Let \( m \) be the string consisting of the digits of the decimal representation of \( n \) (in order, with no leading zeroes).
21. If \( f = 0 \), go to step 24.
22. Let \( a \) be the first character of \( m \), and let \( b \) be the remaining \( f \) characters of \( m \).
23. Let \( m \) be the concatenation of the three strings \( a \), "\"", and \( b \).
24. If \( e = 0 \), let \( c = "+" \) and \( d = "0" \) and go to step 29.
25. If \( e > 0 \), let \( c = "+" \) and go to step 28.
26. Let \( c = "-" \).
27. Let \( e = e \).
28. Let \( d \) be the string consisting of the digits of the decimal representation of \( e \) (in order, with no leading zeroes).
29. Let \( m \) be the concatenation of the four strings \( m \), "\e"", \( c \), and \( d \).
30. Return the concatenation of the strings \( s \) and \( m \).

The length property of the \text{toExponential} \) method is \( 1 \).

If the \text{toExponential} \) method is called with more than one argument, then the behaviour is undefined (see clause 15).

An implementation is permitted to extend the behaviour of \text{toExponential} \) for values of \text{fractionDigits} \) less than 0 or greater than 20. In this case \text{toExponential} \) would not necessarily throw \text{RangeError} \) for such values.

\textit{NOTE}

For implementations that provide more accurate conversions than required by the rules above, it is recommended that the following alternative version of step 19 be used as a guideline:

Let \( s, n, \) and \( f \) be integers such that \( f \geq 0, 10^f \leq n < 10^{f+1} \), the number value for \( n \times 10^{-f} \) is \( x \), and \( f \) is as small as possible. If there are multiple possibilities for \( n \), choose the value of \( n \) for which \( n \times 10^{-f} \) is closest in value to \( x \). If there are two such possible values of \( n \), choose the one that is even.

\subsection{Number.prototype.toPrecision (precision)}

Return a string containing the number represented either in exponential notation with one digit before the significand's decimal point and \text{precision}–1 digits after the significand's decimal point or in fixed notation with \text{precision} significant digits. If \text{precision} \) is \text{undefined} \), call \text{ToString} \) (9.8.1) instead.

Specifically, perform the following steps:
1. Let \( x \) be this number value.
2. If \text{precision} \) is \text{undefined} \), return \text{ToString}(\( x \)).
3. Let \( p \) be \text{TolNeger}(\text{precision}).
4. If \( x \) is \text{NaN}, return the string "\text{NaN}".
5. Let \( x \) be the empty string.
6. If \( x \geq 0 \), go to step 9.
7. Let \( x \) be "-".
8. Let \( x = -x \).
9. If \( x = \infty \), let \( m = \text{"Infinity"} \) and go to step 30.
10. If \( p < 1 \) or \( p > 21 \), throw a \text{RangeError} exception.
11. If \( x \neq 0 \), go to step 15.
12. Let \( m \) be the string consisting of \( p \) occurrences of the character ‘0’.
13. Let \( e = 0 \).
15. Let \( e \) and \( n \) be integers such that \( 10^{p-1} \leq n < 10^p \) and for which the exact mathematical value of \( n \times 10^{p-1} - x \) is as close to zero as possible. If there are two such sets of \( n \) and \( e \), pick the \( e \) and \( n \) for which \( n \times 10^{p-1} \) is larger.
16. Let \( m \) be the string consisting of the digits of the decimal representation of \( n \) (in order, with no leading zeroes).
17. If \( e < -6 \) or \( e \geq p \), go to step 22.
18. If \( e = p-1 \), go to step 30.
19. Let \( e \) and \( n \) be integers such that \( 10^{p-1} \leq n < 10^p \) and for which the exact mathematical value of \( n \times 10^{p-1} - x \) is as close to zero as possible. If there are two such sets of \( n \) and \( e \), pick the \( e \) and \( n \) for which \( n \times 10^{p-1} \) is larger.
20. Let \( m \) be the string consisting of the digits of the decimal representation of \( n \) (in order, with no leading zeroes).
22. Let \( a \) be the first character of \( m \), and let \( b \) be the remaining \( p-1 \) characters of \( m \).
23. Let \( m \) be the concatenation of the three strings \( a \), ‘.‘, and \( b \).
24. If \( e < 0 \), let \( c = +n \) and \( d = 0n \) and go to step 29.
25. If \( e > 0 \), let \( c = +n \) and go to step 28.
26. Let \( c = n \).
27. Let \( e = -e \).
28. Let \( d \) be the string consisting of the digits of the decimal representation of \( e \) (in order, with no leading zeroes).
29. Let \( m \) be the concatenation of the four strings \( m \), ‘e’, \( c \), and \( d \).
30. Return the concatenation of the strings \( s \) and \( m \).

The \text{length} property of the \text{toPrecision} method is 1.

If the \text{toPrecision} method is called with more than one argument, then the behaviour is undefined (see clause 15).

An implementation is permitted to extend the behaviour of \text{toPrecision} for values of \text{precision} less than 1 or greater than 21. In this case \text{toPrecision} would not necessarily throw \text{RangeError} for such values.

### 15.7.4.8 \text{Number.prototype.toJSON ( key )}

When the \text{toJSON} method is called with argument \text{key}, the following steps are taken:

1. Let \( O \) be this object.
2. Call the [[Get]] method of \( O \) with argument ‘valueOf’.
3. If \text{IsCallable}(Result(2)) is false, go to step 6
4. Call the [[Call]] method of Result(2) with \( O \) as the \text{this} value and an empty argument list.
5. If Result(4) is a primitive value, return Result(4).
6. Throw a \text{TypeError} exception.

**NOTE**
The \text{toJSON} function is intentionally generic; it does not require that its \text{this} value be a Number object. Therefore, it can be transferred to other kinds of objects for use as a method.

An object is free to use the argument ‘key’ that is passed in to filter its stringification.

### 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 a single object that has some named properties, some of which are functions.

The value of the internal [[Prototype]] property of the Math object is the Object prototype object (15.2.3.1).

The value of the internal [[Class]] property of the Math object is ‘\text{Math}’.
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.

The Math object does not have a [[Call]] property; it is not possible to invoke the Math object as a function.

**NOTE**
In this specification, the phrase “the number value for \( x \)” has a technical meaning defined in 8.5.

### 15.8.1 Value Properties of the Math Object

#### 15.8.1.1 \( E \)

The number value for the base of the natural logarithms, which is approximately 2.7182818284590452354.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

#### 15.8.1.2 LN10

The number value for the natural logarithm of 10, which is approximately 2.302585092994046.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

#### 15.8.1.3 LN2

The number value for the natural logarithm of 2, which is approximately 0.6931471805599453.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

#### 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.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

**NOTE**
The value of \( Math.LOGB2E \) is approximately the reciprocal of the value of \( Math.LN2 \).

#### 15.8.1.5 LOG10E

The number value for the base-10 logarithm of \( e \), the base of the natural logarithms; this value is approximately 0.4342944819032518.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

**NOTE**
The value of \( Math.LOGB10E \) is approximately the reciprocal of the value of \( Math.LN10 \).

#### 15.8.1.6 PI

The number value for \( \pi \), the ratio of the circumference of a circle to its diameter, which is approximately 3.1415926535897932.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

#### 15.8.1.7 SQRT1_2

The number value for the square root of 1/2, which is approximately 0.7071067811865476.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

**NOTE**
The value of \( Math.SQRT1_2 \) is approximately the reciprocal of the value of \( Math.SQRT2 \).

#### 15.8.1.8 SQRT2

The number value for the square root of 2, which is approximately 1.4142135623730951.

This property has the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

### 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).
In the function descriptions below, the symbols NaN, −0, +0, −∞ and +∞ refer to the number values described in 8.5.

**NOTE**

The behaviour of the functions acos, asin, atan, atan2, cos, exp, log, pow, sin, and sqrt is not precisely specified here except to require specific results for certain argument values that represent boundary cases of interest. For other argument values, these functions 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 implementer 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.

Although the choice of algorithms is left to the implementation, it is recommended (but not specified by this standard) that implementations use the approximation algorithms for IEEE 754 arithmetic contained in fdlibm, the freely distributable mathematical library from Sun Microsystems (fdlibm-comment@sunpro.eng.sun.com). 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 x; the result has the same magnitude as x but has positive sign.

- If x is NaN, the result is NaN.
- If x is −0, the result is +0.
- If x is −∞, the result is +0.

15.8.2.2 **acos** (x)

Returns an implementation-dependent approximation to the arc cosine of x. The result is expressed in radians and ranges from +0 to +π.

- If x is NaN, the result is NaN.
- If x is greater than 1, the result is NaN.
- If x is less than −1, the result is NaN.
- If x is +0, the result is +0.
- If x is −0, the result is +0.

15.8.2.3 **asin** (x)

Returns an implementation-dependent approximation to the arc sine of x. The result is expressed in radians and ranges from −π/2 to +π/2.

- If x is NaN, the result is NaN.
- If x is greater than 1, the result is NaN.
- If x is less than −1, the result is NaN.
- If x is +0, the result is +0.
- If x is −0, the result is −0.

15.8.2.4 **atan** (x)

Returns an implementation-dependent approximation to the arc tangent of x. The result is expressed in radians and ranges from −π/2 to +π/2.

- If x is NaN, the result is NaN.
- If x is +0, the result is +0.
- If x is −0, the result is −0.
- If x is +∞, the result is an implementation-dependent approximation to +π/2.
- If x is −∞, the result is an implementation-dependent approximation to −π/2.

15.8.2.5 **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 y and x 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 x or y 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 a NaN.
If y is +0 and x = 0, the result is +0.
If y > 0 and x = \(+\pi/2\), the result is an implementation-dependent approximation to \(+\pi/2\).
If y > 0 and x = \(-\pi/2\), 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 > 0 and y is finite and x is \(+\infty\), the result is an implementation-dependent approximation to \(+\pi/4\).
If y > 0 and y is finite and x is \(-\infty\), the result is an implementation-dependent approximation to \(+3\pi/4\).
If y > 0 and y is finite and x is \(+\infty\), the result is an implementation-dependent approximation to \(+\pi/4\).
If y > 0 and y is finite 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 x and is equal to a mathematical integer. If x is already an integer, the result is x.

If x is NaN, the result is NaN.
If x is +0, the result is +0.
If x is \(-0\), the result is \(-0\).
If x is \(+\infty\), the result is \(+\infty\).
If x is \(-\infty\), the result is \(-\infty\).
If x 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 x. The argument is expressed in radians.

If x is NaN, the result is NaN.
If x is +0, the result is 1.
If x is \(-0\), the result is 1.
If x is \(+\infty\), the result is NaN.
If x is \(-\infty\), the result is NaN.

15.8.2.8 **exp (x)**

Returns an implementation-dependent approximation to the exponential function of x (e raised to the power of x, where e is the base of the natural logarithms).
If \( x \) is NaN, the result is NaN.
If \( x \) is +0, the result is 1.
If \( x \) is −0, the result is 1.
If \( x \) is +\( \infty \), the result is +\( \infty \).
If \( x \) is −\( \infty \), the result is +0.

15.8.2.9 \texttt{floor} (\( x \))
Returns the greatest (closest to +\( \infty \)) number value that is not greater than \( x \) and is equal to a mathematical integer. If \( x \) is already an integer, the result is \( x \).
If \( x \) is NaN, the result is NaN.
If \( x \) is +0, the result is +0.
If \( x \) is −0, the result is −0.
If \( x \) is +\( \infty \), the result is +\( \infty \).
If \( x \) is −\( \infty \), the result is −\( \infty \).
If \( x \) is greater than 0 but less than 1, the result is +0.

\textit{NOTE}
The value of Math.floor(\( x \)) is the same as the value of -Math.ceil(-\( x \)).

15.8.2.10 \texttt{log} (\( x \))
Returns an implementation-dependent approximation to the natural logarithm of \( x \).
If \( x \) is NaN, the result is NaN.
If \( x \) is less than 0, the result is NaN.
If \( x \) is +0 or −0, the result is −\( \infty \).
If \( x \) is 1, the result is +0.
If \( x \) is +\( \infty \), the result is +\( \infty \).

15.8.2.11 \texttt{max} (\{ value1 \, value2 \, \ldots \, \})
Given zero or more arguments, calls ToNumber on each of the arguments and returns the largest of the resulting values.
If no arguments are given, the result is −\( \infty \).
If any value is NaN, the result is NaN.
The comparison of values to determine the largest value is done as in 11.8.5 except that +0 is considered to be larger than −0.
The \texttt{length} property of the \texttt{max} method is 2.

15.8.2.12 \texttt{min} (\{ value1 \, value2 \, \ldots \, \})
Given zero or more arguments, calls ToNumber on each of the arguments and returns the smallest of the resulting values.
If no arguments are given, the result is +\( \infty \).
If any value is NaN, the result is NaN.
The comparison of values to determine the smallest value is done as in 11.8.5 except that +0 is considered to be larger than −0.
The \texttt{length} property of the \texttt{min} method is 2.

15.8.2.13 \texttt{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.

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If \(x\) is NaN and \(y\) is nonzero, the result is NaN.
If \(|x| > 1\) and \(y\) is +\(\infty\), the result is +\(\infty\).
If \(|x| > 1\) and \(y\) is -\(\infty\), the result is +0.
If \(|x| = 1\) and \(y\) is +\(\infty\), the result is NaN.
If \(|x| = 1\) and \(y\) is -\(\infty\), the result is NaN.
If \(|x| < 1\) and \(y\) is +\(\infty\), the result is +0.
If \(|x| < 1\) and \(y\) is -\(\infty\), the result is +0.
If \(x\) is +\(\infty\) and \(y > 0\), the result is +0.
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 \(y > 0\) 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 0.
If \(x\) is 0 and \(y < 0\) and \(y\) is not an odd integer, the result is +0.
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 pseudo randomly 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 \(x\) and is equal to a mathematical integer. If two integer number values are equally close to \(x\), then the result is the number value that is closer to +\(\infty\). If \(x\) is already an integer, the result is \(x\).
If \(x\) is NaN, the result is NaN.
If \(x\) is +0, the result is +0.
If \(x\) is -0, the result is -0.
If \(x\) is +\(\infty\), the result is +\(\infty\).
If \(x\) is -\(\infty\), the result is -\(\infty\).
If \(x\) is greater than 0 but less than 0.5, the result is +0.
If \(x\) is less than 0 but greater than or equal to -0.5, the result is -0.

**NOTE 1**
Math.round(3.5) returns 4, but Math.round(-3.5) returns -3.

**NOTE 2**
The value of Math.round(\(x\)) is the same as the value of Math.floor(\(x+0.5\)), except when \(x\) is -0 or is less than 0 but greater than or equal to -0.5; for these cases 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 \(x\). The argument is expressed in radians.
If \(x\) is NaN, the result is NaN.
If \(x\) is +0, the result is +0.
If \(x\) is -0, the result is -0.

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If \( x \) is \(+\infty\) or \(-\infty\), the result is NaN.

15.8.2.17 \( \sqrt{x} \)
Returns an implementation-dependent approximation to the square root of \( x \).
If \( x \) is NaN, the result is NaN.
If \( x \) is less than 0, the result is NaN.
If \( x \) is \(+0\), the result is \(+0\).
If \( x \) is \(-0\), the result is \(-0\).
If \( x \) is \(+\infty\), the result is \(+\infty\).

15.8.2.18 \( \tan(x) \)
Returns an implementation-dependent approximation to the tangent of \( x \). The argument is expressed in radians.
If \( x \) is NaN, the result is NaN.
If \( x \) is \(+0\), the result is \(+0\).
If \( x \) is \(-0\), the result is \(-0\).
If \( x \) is \(+\infty\) or \(-\infty\), the result is NaN.

15.9 Date Objects
15.9.1 Overview of Date Objects and Definitions of Internal Operators
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 \(-9,007,199,254,740,991\) to \(9,007,199,254,740,991\); 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.

The exact moment of midnight at the beginning of 01 January, 1970 UTC is represented by the value \(+0\).

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:
\[
\text{TimeWithinDay}(t) = t \mod \text{msPerDay}
\]

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:

\[
\text{DaysInYear}(y) = \begin{cases} 
365 & \text{if } (y \mod 4) \neq 0 \\
366 & \text{if } (y \mod 4) = 0 \text{ and } (y \mod 100) \neq 0 \\
365 & \text{if } (y \mod 100) = 0 \text{ and } (y \mod 400) \neq 0 \\
366 & \text{if } (y \mod 400) = 0 
\end{cases}
\]

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:

\[
\text{DayFromYear}(y) = 365 \times (y-1901) + \lfloor \text{floor}(y \mod 400) \rfloor \\
\]

The time value of the start of a year is:

\[
\text{TimeFromYear}(t) = \text{msPerDay} \times \text{DayFromYear}(y)
\]

A time value determines a year by:

\[
\text{YearFromTime}(t) = \text{the largest integer } y \text{ (closest to positive infinity) such that } \text{TimeFromYear}(y) \leq t
\]

The leap-year function is 1 for a time within a leap year and otherwise is zero:

\[
\text{InLeapYear}(t) = \begin{cases} 
0 & \text{if } \text{DaysInYear}(\text{YearFromTime}(t)) = 365 \\
1 & \text{if } \text{DaysInYear}(\text{YearFromTime}(t)) = 366
\end{cases}
\]

### 15.9.1.4 Month Number

Months are identified by an integer in the range 0 to 11, inclusive. The mapping \( \text{MonthFromTime}(t) \) from a time value \( t \) to a month number is defined by:

\[
\text{MonthFromTime}(t) = \begin{cases} 
0 & \text{if } 0 \leq \text{DayWithinYear}(t) < 31 \\
1 & \text{if } 31 \leq \text{DayWithinYear}(t) < 59 + \text{InLeapYear}(t) \\
2 & \text{if } 59 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 90 + \text{InLeapYear}(t) \\
3 & \text{if } 90 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 120 + \text{InLeapYear}(t) \\
4 & \text{if } 120 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 151 + \text{InLeapYear}(t) \\
5 & \text{if } 151 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 181 + \text{InLeapYear}(t) \\
6 & \text{if } 181 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 212 + \text{InLeapYear}(t) \\
7 & \text{if } 212 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 243 + \text{InLeapYear}(t) \\
8 & \text{if } 243 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 273 + \text{InLeapYear}(t) \\
9 & \text{if } 273 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 304 + \text{InLeapYear}(t) \\
10 & \text{if } 304 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 334 + \text{InLeapYear}(t) \\
11 & \text{if } 334 + \text{InLeapYear}(t) \leq \text{DayWithinYear}(t) < 365 + \text{InLeapYear}(t)
\end{cases}
\]

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:

\[
\text{DateFromTime}(t) = \begin{cases} 
\text{DayWithinYear}(t) + 1 & \text{if } \text{MonthFromTime}(t) = 0 \\
\text{DayWithinYear}(t) + 30 & \text{if } \text{MonthFromTime}(t) = 1 \\
\text{DayWithinYear}(t) + 58 + \text{InLeapYear}(t) & \text{if } \text{MonthFromTime}(t) = 2 \\
\text{DayWithinYear}(t) + 89 + \text{InLeapYear}(t) & \text{if } \text{MonthFromTime}(t) = 3 \\
\text{DayWithinYear}(t) + 119 + \text{InLeapYear}(t) & \text{if } \text{MonthFromTime}(t) = 4 \\
\text{DayWithinYear}(t) + 150 + \text{InLeapYear}(t) & \text{if } \text{MonthFromTime}(t) = 5 \\
\text{DayWithinYear}(t) + 180 + \text{InLeapYear}(t) & \text{if } \text{MonthFromTime}(t) = 6 \\
\text{DayWithinYear}(t) + 211 + \text{InLeapYear}(t) & \text{if } \text{MonthFromTime}(t) = 7
\end{cases}
\]
15.9.1.6  Week Day

The weekday for a particular time value \( t \) is defined as

\[
\text{WeekDay}(t) = (\text{Day}(t) + 4) \mod 7
\]

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 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. The local time zone adjustment is a value 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. The algorithm to determine the daylight saving time adjustment DaylightSavingTA(\( t \)), measured in milliseconds, must depend only on four things:

1. the time since the beginning of the year
   \( t - \text{TimeFromYear(yearFromTime}(t)) \)
2. whether \( t \) is in a leap year
   InLeapYear(\( t \))
3. the week day of the beginning of the year
   WeekDay(\( \text{TimeFromYear(yearFromTime}(t)) \))
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 locale observed daylight saving time year round.

If the host environment 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 host environment 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 UTC(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:

\[
\text{HourFromTime}(t) = \text{floor}(t / \text{msPerHour}) \mod \text{HoursPerDay}
\]

\[
\text{MinFromTime}(t) = \text{floor}(t / \text{msPerMinute}) \mod \text{MinutesPerHour}
\]

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SecFromTime(t) = \lfloor t / \text{msPerSecond} \rfloor \mod \text{SecondsPerMinute}
msFromTime(t) = t \mod \text{msPerSecond}

where
HoursPerDay = 24
MinutesPerHour = 60
SecondsPerMinute = 60
msPerSecond = 1000
msPerMinute = msPerSecond \times \text{SecondsPerMinute} = 60000
msPerHour = msPerMinute \times \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 `Result(2) \times \text{msPerHour} + Result(3) \times \text{msPerMinute} + Result(4) \times \text{msPerSecond} + 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 `Result(2) + \lfloor Result(3)/12 \rfloor`.
6. Compute `Result(3) \mod 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 `Day(Result(7)) + Result(4)`.
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 `day \times \text{msPerDay} + time`.
3. Return `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 `abs(Result(1)) > 8.64 \times 10^{15}`, return `NaN`.

Comment [pL53]: From AWB: Need to define TimeValue and make it clear that a TimeValue is what this function returns. Needed for Date.now().
3. Return an implementation-dependent choice of either ToInteger(Result(2)) or ToInteger(Result(2)) + (+0).
   (Adding a positive zero converts –0 to +0.)

**NOTE**

The point of step 3 is that an implementation is permitted a choice of internal representations of time values, for example as a 64-bit signed integer or as a 64-bit floating-point value. Depending on the implementation, this internal representation may or may not distinguish –0 and +0.

### 15.9.1.15 Date Time string format

The Simplified ISO 8601 format is as follows: **YYYY-MM-DDTHH:mm:ss.sss**

Where the fields are as follows:

- **YYYY** is the year in the Gregorian calendar
- **MM** is the month of the year between 01 (January) and 12 (December)
- **DD** is the day of the month between 01 and 31.
- The “T” appears literally in the string, to indicate the beginning of the time element, as specified in ISO 8601.
- **HH** is the number of complete hours that have passed since midnight
- **mm** is the number of complete minutes since the start of the hour
- **ss** is the number of complete seconds since the start of the minute
- The ‘.’ (dot)
- **sss** is the number of complete milliseconds since the start of the second.
- Both the ‘.’ And the milliseconds field are optional
- **TZ** is the timezone specified as **Z** (for UTC) or either + or – followed by a time expression **HH:MM**

**Extended years**

ECMAScript requires the ability to specify 6 digit years (extended years); approximately 285,616 years, either forward or backward, from 01 January, 1970 UTC. To represent years before 0 or after 9999, ISO 8601 permits the expansion of the year representation, but only by prior agreement between the sender and the receiver. In the simplified ECMAScript format such an expanded year representation shall have 2 extra year digits and is always prefixed with a + or – sign with the convention that year 0 is positive.

**NOTE**

This format includes date-only forms:

- **YYYY**
- **YYYY-MM**
- **YYYY-MM-DD**

Time-only forms with an optional time zone appended:

- **THH:mm**
- **THH:mm:ss**
- **THH:mm:ss.sss**

It also includes “date-times” which could be any combination of the above.

All numbers must be base 10.

Illegal values (out-of-bounds as well as syntax errors) in a format string means that the format string is not a valid instance of this format.

As every day both starts and ends with midnight, the two notations 00:00 and 24:00 are available to distinguish the two midnights that can be associated with one date. This means that the following two notations refer to exactly the same point in time: 1995-02-04T24:00 and 1995-02-05T00:00.
There exists no international standard that specifies abbreviations for civil time zones like CET, EST, etc. and sometimes the same abbreviation is even used for two very different time zones. For this reason, ISO 8601 and this format specifies numeric representations of date and time.

15.9.2 The Date Constructor Called as a Function
When \texttt{Date} is called as a function rather than as a constructor, it returns a string representing the current time (UTC).

\textbf{NOTE}\n
The function call \texttt{Date(...)} is not equivalent to the object creation expression \texttt{new Date(...)} with the same arguments.

15.9.2.1 \texttt{Date([year[, month[, date[, hours[, minutes[, seconds[, ms]]]]]])}
All of the arguments are optional; any arguments supplied are accepted but are completely ignored. A string is created and returned as if by the expression (\texttt{new Date()}.\texttt{toString()} where \texttt{Date} is the standard built-in constructor with that name and \texttt{toString} is the standard built-in method \texttt{Date.prototype.toString}.

15.9.3 The Date Constructor
When \texttt{Date} is called as part of a \texttt{new} expression, it is a constructor: it initialises the newly created object.

15.9.3.1 \texttt{new Date(year, month[, date[, hours[, minutes[, seconds[, ms]]]]])}
When \texttt{Date} is called with two to seven arguments, it computes the date from year, month, and (optionally) date, hours, minutes, seconds and ms.

The \texttt{[[Prototype]]} property of the newly constructed object is set to the original Date prototype object, the one that is the initial value of \texttt{Date.prototype (15.9.4.1)}.

The \texttt{[[Class]]} property of the newly constructed object is set to "\texttt{Date}".

The \texttt{[[Extensible]]} property of the newly constructed object is set to true.

The \texttt{[[PrimitiveValue]]} property of the newly constructed object is set as follows:
1. Call \texttt{ToNumber(year)}.
2. Call \texttt{ToNumber(month)}.
3. If \texttt{date} is supplied use \texttt{ToNumber(date)}; else use 1.
4. If \texttt{hours} is supplied use \texttt{ToNumber(hours)}; else use 0.
5. If \texttt{minutes} is supplied use \texttt{ToNumber(minutes)}; else use 0.
6. If \texttt{seconds} is supplied use \texttt{ToNumber(seconds)}; else use 0.
7. If \texttt{ms} is supplied use \texttt{ToNumber(ms)}; else use 0.
8. If Result(1) is not \texttt{NaN} and 0 ≤ Result(1) ≤ 99, Result(8) is 1900+\texttt{ToInteger(Result(1))}; otherwise, Result(8) is Result(1).
9. Compute \texttt{MakeDay(Result(8), Result(2), Result(3))}.
10. Compute \texttt{MakeTime(Result(4), Result(5), Result(6), Result(7))}.
11. Compute \texttt{MakeDate(Result(9), Result(10))}.
12. Set the \texttt{[[PrimitiveValue]]} property of the newly constructed object to \texttt{TimeClip(UTC(Result(1)))}.

15.9.3.2 \texttt{new Date(value)}
The \texttt{[[Prototype]]} property of the newly constructed object is set to the original Date prototype object, the one that is the initial value of \texttt{Date.prototype (15.9.4.1)}.

The \texttt{[[Class]]} property of the newly constructed object is set to "\texttt{Date}".

The \texttt{[[Extensible]]} property of the newly constructed object is set to true.

The \texttt{[[PrimitiveValue]]} property of the newly constructed object is set as follows:
1. Call \texttt{ToPrimitive(value)}.
2. If Type(Result(1)) is String, then go to step 5.
3. Let \texttt{V} be \texttt{ToNumber(Result(1))}.
4. Set the \texttt{[[PrimitiveValue]]} property of the newly constructed object to \texttt{TimeClip(V)} and return.
5. Parse Result(1) as a date, in exactly the same manner as for the `parse` method (15.9.4.2); let V be the time value for this date.

15.9.3.3 new Date ()

The [[Prototype]] property of the newly constructed object is set to the original Date prototype object, the one that is the initial value of `Date.prototype` (15.9.4.1).

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

The [[Extensible]] property of the newly constructed object is set to `true`.

The [[PrimitiveValue]] property of the newly constructed object is set to the current time (UTC).

15.9.4 Properties of the Date Constructor

The value of the internal [[Prototype]] property of the Date constructor is the Function prototype object (15.3.4).

Besides the internal properties and the `length` property (whose value is 7), the Date constructor has the following properties:

15.9.4.1 Date.prototype

The initial value of `Date.prototype` is the built-in Date prototype object (15.9.5).

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.9.4.2 Date.parse (string)

The `parse` function applies the `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. The function first attempts to parse the format of the string according to the rules called out in Date Time String Format (15.9.1.15). If the string does not conform to that format the function may fall back to any implementation-specific heuristics or implementation-specific date formats. Unrecognizable strings or dates containing illegal element values in the format string shall cause `Date.parse` to return NaN.

If `x` is any Date object whose milliseconds amount is zero 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:

\[
\begin{align*}
x & .valueOf() \\
\text{Date.parse}(x .toString()) \\
\text{Date.parse}(x .toUTCString()) \\
\text{Date.parse}(x .toLocaleString())
\end{align*}
\]

However, the expression

\[
\text{Date.parse}(x .toLocaleString())
\]

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 `toUTCString` method.

15.9.4.3 Date.UTC (year, month [, date [, hours [, minutes [, seconds [, ms ] ] ] ] ] )

When the `UTC` function is called with fewer than two arguments, the behaviour is implementation-dependent. When the `UTC` function is called with two to seven arguments, it computes the date from `year`, `month` and (optionally) `date`, `hours`, `minutes`, `seconds` and `ms`. The following steps are taken:

1. Call `ToNumber(year)`.
2. Call `ToNumber(month)`.
3. If `date` is supplied use `ToNumber(date)`; else use 1.
4. If `hours` is supplied use `ToNumber(hours)`; else use 0.
5. If `minutes` is supplied use `ToNumber(minutes)`; else use 0.
6. If `seconds` is supplied use `ToNumber(seconds)`; else use 0.
7. If \( ms \) is supplied use \( \text{ToNumber}(ms) \); else use 0.
8. If Result(1) is not \( \text{NaN} \) and \( 0 \leq \text{ToInteger(Result(1))} \leq 99 \), Result(8) is \( 1900+\text{ToInteger(Result(1))} \); 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 TimeClip(MakeDate(Result(9), Result(10))).

The \texttt{length} property of the \texttt{UTC} function is 7.

\textbf{NOTE}
The \texttt{UTC} function differs from the \texttt{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.

15.9.4.4 \texttt{Date.now()} 

The \texttt{now} method produces the \texttt{time value} at the time of the call.

15.9.5 \textbf{Properties of the Date Prototype Object}

The Date prototype object is itself a Date object (its \texttt{[[Class]]} is \texttt{"Date"}) whose value is \texttt{NaN}.

The value of the internal \texttt{[[Prototype]]} property of the Date prototype object is the Object prototype object (15.2.3.1).

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 \texttt{this} value for the invocation of the function. None of these functions are generic; a \texttt{TypeError} exception is thrown if the \texttt{this} value is not an object for which the value of the internal \texttt{[[Class]]} property is \texttt{"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 \texttt{[[PrimitiveValue]]} property of this Date object.

15.9.5.1 \texttt{Date.prototype.constructor}

The initial value of \texttt{Date.prototype.constructor} is the built-in \texttt{Date} constructor.

15.9.5.2 \texttt{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 the current time zone in a convenient, human-readable form.

\textbf{NOTE}. For any Date value \( d \) whose milliseconds amount is zero, the result of \texttt{Date.prototype.parse(d.toString())} (15.9.4.2) is equal to \texttt{d.valueOf()}. See section 15.9.4.2.

15.9.5.3 \texttt{Date.prototype.toDateString()} 

This function returns a string value. The contents of the string are implementation-dependent, but are intended to represent the “date” portion of the Date in the current time zone in a convenient, human-readable form.

15.9.5.4 \texttt{Date.prototype.toTimeString()} 

This function returns a string value. The contents of the string are implementation-dependent, but are intended to represent the “time” portion of the Date in the current time zone in a convenient, human-readable form.

15.9.5.5 \texttt{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 the current time zone in a convenient, human-readable form that corresponds to the conventions of the host environment’s current locale.

\textbf{NOTE}
The first parameter to this function is likely to be used in a future version of this standard; it is recommended that implementations do not use this parameter position for anything else.

15.9.5.6 \texttt{Date.prototype.toLocaleDateString()} 

This function returns a string value. The contents of the string are implementation-dependent, but are intended to return the “date” portion of the Date in the current time zone in a convenient, human-readable form that corresponds to the conventions of the host environment’s current locale.

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NOTE
The first parameter to this function is likely to be used in a future version of this standard; it is
recommended that implementations do not use this parameter position for anything else.

15.9.5.7  `Date.prototype.toLocaleTimeString()` ()
This function returns a string value. The contents of the string are implementation-dependent, but are
intended to represent the “time” portion of the Date in the current time zone in a convenient, human-
readable form that corresponds to the conventions of the host environment’s current locale.

NOTE
The first parameter to this function is likely to be used in a future version of this standard; it is
recommended that implementations do not use this parameter position for anything else.

15.9.5.8  `Date.prototype.valueOf()` ()
The `valueOf` function returns a number, which is this time value.

15.9.5.9  `Date.prototype.getTime()` ()
1. If the `this` value is not an object whose `[[Class]]` property is "Date", throw a `TypeError`
   exception.
2. Return this time value.

15.9.5.10  `Date.prototype.getFullYear()` ()
1. Let t be this time value.
2. If t is `NaN`, return `NaN`.
3. Return `YearFromTime(LocalTime(t))`.

15.9.5.11  `Date.prototype.getUTCFullYear()` ()
1. Let t be this time value.
2. If t is `NaN`, return `NaN`.
3. Return `YearFromTime(t)`.

15.9.5.12  `Date.prototype.getMonth()` ()
1. Let t be this time value.
2. If t is `NaN`, return `NaN`.
3. Return `MonthFromTime(LocalTime(t))`.

15.9.5.13  `Date.prototype.getUTCMonth()` ()
1. Let t be this time value.
2. If t is `NaN`, return `NaN`.
3. Return `MonthFromTime(t)`.

15.9.5.14  `Date.prototype.getDate()` ()
1. Let t be this time value.
2. If t is `NaN`, return `NaN`.
3. Return `DateFromTime(LocalTime(t))`.

15.9.5.15  `Date.prototype.getUTCDate()` ()
1. Let t be this time value.
2. If t is `NaN`, return `NaN`.
3. Return `DateFromTime(t)`.

15.9.5.16  `Date.prototype.getDay()` ()
1. Let t be this time value.
2. If t is `NaN`, return `NaN`.
3. Return `WeekDay(LocalTime(t))`.

15.9.5.17  `Date.prototype.getUTCDay()` ()
1. Let t be this time value.

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2. If \( t \) is NaN, return NaN.
3. Return WeekDay(\( t \)).

15.9.5.18 \texttt{Date.prototype.getHours ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return HourFromTime(LocalTime(\( t \))).

15.9.5.19 \texttt{Date.prototype.getUTCHours ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return HourFromTime(\( t \)).

15.9.5.20 \texttt{Date.prototype.getMinutes ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return MinFromTime(LocalTime(\( t \))).

15.9.5.21 \texttt{Date.prototype.getUTCMinutes ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return MinFromTime(\( t \)).

15.9.5.22 \texttt{Date.prototype.getSeconds ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return SecFromTime(LocalTime(\( t \))).

15.9.5.23 \texttt{Date.prototype.getUTCSeconds ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return SecFromTime(\( t \)).

15.9.5.24 \texttt{Date.prototype.getMilliseconds ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return msFromTime(LocalTime(\( t \))).

15.9.5.25 \texttt{Date.prototype.getUTCMilliseconds ( )}
1. Let \( t \) be this time value.
2. If \( t \) is NaN, return NaN.
3. Return msFromTime(\( t \)).

15.9.5.26 \texttt{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})

15.9.5.27 \texttt{Date.prototype.setTime (time)}
1. If the \texttt{this} value is not a Date object, throw a \texttt{TypeError} exception.
2. Call \texttt{ToNumber} \( (time) \).
3. Call \texttt{TimeClip(Result(1))}.
4. Set the \([\text{PrimitiveValue}]\) property of the \texttt{this} value to Result(2).
5. Return the value of the \([\text{PrimitiveValue}]\) property of the \texttt{this} value.
15.9.5.28 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 [[PrimitiveValue]] property of the this value to TimeClip(Result(4)).
6. Return the value of the [[PrimitiveValue]] property of the this value.

15.9.5.29 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 [[PrimitiveValue]] property of the this value to TimeClip(Result(4)).
6. Return the value of the [[PrimitiveValue]] property of the this value.

15.9.5.30 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(\( t \)), SecFromTime(\( t \)), Result(2), Result(3)).
5. Compute UTC(MakeDate(Day(\( t \)), Result(4))).
6. Set the [[PrimitiveValue]] property of the this value to TimeClip(Result(5)).
7. Return the value of the [[PrimitiveValue]] property of the this value.
The length property of the setSeconds method is 2.

15.9.5.31 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 UTC(MakeDate(Day(\( t \)), Result(4))).
6. Set the [[PrimitiveValue]] property of the this value to TimeClip(Result(5)).
7. Return the value of the [[PrimitiveValue]] property of the this value.
The length property of the setUTCSeconds method is 2.

15.9.5.33 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 [[PrimitiveValue]] property of the this value to TimeClip(Result(6)).
8. Return the value of the [[PrimitiveValue]] property of the this value.
The length property of the setMinutes method is 3.

15.9.5.34 Date.prototype.setUTCMinutes (min [, sec [, ms ] ] )
If sec is not specified, this behaves as if sec were specified with the value getUTCSeconds( ).

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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 [[PrimitiveValue]] property of the this value to TimeClip(Result(6)).
8. Return the value of the [[PrimitiveValue]] property of the this value.

The length property of the setUTCMilliseconds method is 3.

15.9.5.35 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 UTCSeconds().
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 UTC(MakeDate(Day(t), Result(6))).
8. Set the [[PrimitiveValue]] property of the this value to TimeClip(Result(7)).
9. Return the value of the [[PrimitiveValue]] property of the this value.

The length property of the setUTCHours method is 4.

15.9.5.36 Date.prototype.setUTCDate (date)

1. Let t be this time value.
2. Call ToNumber(date).
3. Compute Day(YearFromTime(t), MonthFromTime(t), Result(2)).
4. Compute MakeDate(Result(3), TimeWithinDay(t)).
5. Set the [[PrimitiveValue]] property of the this value to TimeClip(Result(4)).
6. Return the value of the [[PrimitiveValue]] property of the this value.

15.9.5.37 Date.prototype.setUTCDate (date)

1. Let t be this time value.
2. Call ToNumber(date).
3. Compute \( \text{MakeDay}(\text{YearFromTime}(t), \text{MonthFromTime}(t), \text{Result}(2)) \).
4. Compute \( \text{MakeDate}(\text{Result}(3), \text{TimeWithinDay}(t)) \).
5. Set the \([\text{PrimitiveValue}]\) property of the \textit{this} value to TimeClip(\text{Result}(4)).
6. Return the value of the \([\text{PrimitiveValue}]\) property of the \textit{this} value.

15.9.5.38 \texttt{Date.prototype.setMonth (month [, date ] )}
If \textit{date} is not specified, this behaves as if \textit{date} were specified with the value \texttt{getDateTime( )}.
1. Let \( t \) be the result of \texttt{LocalTime(this time value)}.
2. Call \texttt{ToNumber(month)}.
3. If \textit{date} is not specified, compute \texttt{DateFromTime(\( t \))}; otherwise, call \texttt{ToNumber(date)}.
4. Compute \texttt{MakeDay(YearFromTime(\( t \)), Result(2), Result(3))}.
5. Compute \texttt{UTC(MakeDate(Result(4), TimeWithinDay(\( t \))))}.
6. Set the \([\text{PrimitiveValue}]\) property of the \textit{this} value to TimeClip(\text{Result}(5)).
7. Return the value of the \([\text{PrimitiveValue}]\) property of the \textit{this} value.

The \texttt{length} property of the \texttt{setMonth} method is \texttt{2}.

15.9.5.39 \texttt{Date.prototype.setUTCMonth (month [, date ] )}
If \textit{date} is not specified, this behaves as if \textit{date} were specified with the value \texttt{getUTCDatetime( )}.
1. Let \( t \) be this time value.
2. Call \texttt{ToNumber(month)}.
3. If \textit{date} is not specified, compute \texttt{DateFromTime(\( t \))}; otherwise, call \texttt{ToNumber(date)}.
4. Compute \texttt{MakeDay(YearFromTime(\( t \)), Result(2), Result(3))}.
5. Compute \texttt{MakeDate(Result(4), TimeWithinDay(\( t \))))}.
6. Set the \([\text{PrimitiveValue}]\) property of the \textit{this} value to TimeClip(\text{Result}(5)).
7. Return the value of the \([\text{PrimitiveValue}]\) property of the \textit{this} value.

The \texttt{length} property of the \texttt{setUTCMonth} method is \texttt{2}.

15.9.5.40 \texttt{Date.prototype.setFullYear (year [, month [, date ] ] )}
If \textit{month} is not specified, this behaves as if \textit{month} were specified with the value \texttt{getMonth( )}.
If \textit{date} is not specified, this behaves as if \textit{date} were specified with the value \texttt{getDate( )}.
1. Let \( t \) be the result of \texttt{LocalTime(this time value)}; but if this time value is \texttt{NaN}, let \( t \) be \texttt{+0}.
2. Call \texttt{ToNumber(year)}.
3. If \textit{month} is not specified, compute \texttt{MonthFromTime(\( t \))}; otherwise, call \texttt{ToNumber(month)}.
4. If \textit{date} is not specified, compute \texttt{DateFromTime(\( t \))}; otherwise, call \texttt{ToNumber(date)}.
5. Compute \texttt{MakeDay(Result(2), Result(3), Result(4))}.
6. Compute \texttt{UTC(MakeDate(Result(5), TimeWithinDay(\( t \))))}.
7. Set the \([\text{PrimitiveValue}]\) property of the \textit{this} value to TimeClip(\text{Result}(6)).
8. Return the value of the \([\text{PrimitiveValue}]\) property of the \textit{this} value.

The \texttt{length} property of the \texttt{setFullYear} method is \texttt{3}.

15.9.5.41 \texttt{Date.prototype.setUTCFullYear (year [, month [, date ] ] )}
If \textit{month} is not specified, this behaves as if \textit{month} were specified with the value \texttt{getUTCMonth( )}.
If \textit{date} is not specified, this behaves as if \textit{date} were specified with the value \texttt{getUTCDatetime( )}.
1. Let \( t \) be this time value; but if this time value is \texttt{NaN}, let \( t \) be \texttt{+0}.
2. Call \texttt{ToNumber(year)}.
3. If \textit{month} is not specified, compute \texttt{MonthFromTime(\( t \))}; otherwise, call \texttt{ToNumber(month)}.
4. If \textit{date} is not specified, compute \texttt{DateFromTime(\( t \))}; otherwise, call \texttt{ToNumber(date)}.
5. Compute \texttt{MakeDay(Result(2), Result(3), Result(4))}.
6. Compute \texttt{MakeDate(Result(5), TimeWithinDay(\( t \))))}.
7. Set the \([\text{PrimitiveValue}]\) property of the \textit{this} value to TimeClip(\text{Result}(6)).
8. Return the value of the \([\text{PrimitiveValue}]\) property of the \textit{this} value.

The \texttt{length} property of the \texttt{setUTCFullYear} method is \texttt{3}.
15.9.5.42 **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.

NOTE: the intent is produce string representation of a date that is more readable than the format specified in Section 15.9.1.15. It is not essential that the chosen format be unambiguous or easily machine parsable. If an implementation does not have a preferred human-readable format it is recommended to use the format called out in Section 15.9.1.15 but with a space rather than a “-” used to separate the date and time elements.

15.9.5.43 **Date.prototype.toISOString ()**

This function returns a string value. The format of the string is as called out in Date Time string format (15.9.1.15). All fields are present in the string. The time zone is always UTC, denoted by the suffix Z.

15.9.5.44 **Date.prototype.toJSON (key)**

This function returns the same string as Date.prototype.toISOString().

When the toJSON method is called with argument key, the following steps are taken:

1. Let O be this object.
2. Call the [[Get]] method of O with argument “toISOString”.
3. If IsCallable(Result(2)) is false, go to step 6.
4. Call the [[Call]] method of Result(2) with O as the this value and an empty argument list.
5. If Result(4) is a primitive value, return Result(4).
6. Throw a TypeError exception.

NOTE
The toJSON function is intentionally generic; it does not require that its this value be a Date object. Therefore, it can be transferred to other kinds of objects for use as a method. An object is free to use the argument ‘key’ that is passed in to filter its stringification.

15.9.6 **Properties of Date Instances**

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

15.10 **RegExp (Regular Expression) Objects**

A RegExp object contains a regular expression and the associated flags.

NOTE
The form and functionality of regular expressions is modelled after the regular expression facility in the Perl 5 programming language.

15.10.1 **Patterns**

The RegExp constructor applies the following grammar to the input pattern string. An error occurs if the grammar cannot interpret the string as an expansion of Pattern.

**Syntax**

Pattern ::=
  Disjunction

Disjunction ::=
  Alternative
  Alternative | Disjunction

Alternative ::=
  {}empty
  Alternative Term

Term ::=
  Assertion
  Atom
  Atom Quantifier

Comment [pL55]: From AWB:

Need to make it clear that the string is derived from this date object’s internal date value.
Assertion ::
  ^
  $ \
  \

Quantifier ::
  QuantifierPrefix
  QuantifierPrefix ?

QuantifierPrefix ::
  *
  +
  ?
  { DecimalDigits }
  { DecimalDigits , }
  { DecimalDigits , DecimalDigits }

Atom ::
  PatternCharacter
  .
  \ AtomEscape
  CharacterClass
    { Disjunction }
    ( ? : Disjunction )
    ( ? = Disjunction )
    ( ? ! Disjunction )

PatternCharacter :: SourceCharacter but not any of:
  ^ $ \ . * + ? ( ) [ ] { } |

AtomEscape ::
  DecimalEscape
  CharacterEscape
  CharacterClassEscape

CharacterEscape ::
  ControlEscape
  ControlLetter
  HexEscapeSequence
  UnicodeEscapeSequence
  IdentityEscape

ControlEscape :: one of
  f n r t v

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

IdentityEscape ::
  SourceCharacter but not IdentifierPart

DecimalEscape ::
  DecimalIntegerLiteral [lookahead @ DecimalDigit]

CharacterClassEscape :: one of
  d D s S w W
CharacterClass ::
  [ [lookahead ∈ [*]] ClassRanges ]
  [ ^ ClassRanges ]

ClassRanges ::
  [empty]
NonemptyClassRanges

NonemptyClassRanges ::
  ClassAtom
  ClassAtom NonemptyClassRangesNoDash
  ClassAtom ~ ClassAtom ClassRanges

NonemptyClassRangesNoDash ::
  ClassAtom
  ClassAtomNoDash NonemptyClassRangesNoDash
  ClassAtomNoDash ~ ClassAtom ClassRanges

ClassAtom ::
  ~
ClassAtomNoDash

ClassAtomNoDash ::
  SourceCharacter but not one of \ ] ~
  \ ClassEscape

ClassEscape ::
  DecimalEscape
  b
  CharacterEscape
  CharacterClassEscape

15.10.2 Pattern Semantics
A regular expression pattern is converted into an internal function using the process described below. An implementation is encouraged to use more efficient algorithms than the ones listed below, as long as the results are the same.

15.10.2.1 Notation
The descriptions below use the following variables:
Input is the string being matched by the regular expression pattern. The notation input[n] means the nth character of input, where n can range between 0 (inclusive) and InputLength (exclusive).
InputLength is the number of characters in the Input string.
NcapturingParens is the total number of left capturing parentheses (i.e. the total number of times the Atom :: ( Disjunction ) production is expanded) in the pattern. A left capturing parenthesis is any ( pattern character that is matched by the ( terminal of the Atom :: ( Disjunction ) production.
IgnoreCase is the setting of the RegExp object's ignoreCase property.
Multiline is the setting of the RegExp object's multiline property.

Furthermore, the descriptions below use the following internal data structures:
A CharSet is a mathematical set of characters.
A State is an ordered pair (endIndex, captures) where endIndex is an integer and captures is an internal array of NcapturingParens values. States are used to represent partial match states in the regular expression matching algorithms. The endIndex is one plus the index of the last input character matched so far by the pattern, while captures holds the results of capturing parentheses. The nth element of captures is either a string that represents the value obtained by the nth set of capturing parentheses or undefined if the nth set of capturing parentheses hasn’t been reached yet. Due to backtracking, many states may be in use at any time during the matching process.
A `MatchResult` is either a State or the special token `failure` that indicates that the match failed.

A `Continuation` function is an internal closure (i.e. an internal function with some arguments already bound to values) that takes one State argument and returns a `MatchResult` result. If an internal closure references variables bound in the function that creates the closure, the closure uses the values that these variables had at the time the closure was created. The continuation attempts to match the remaining portion (specified by the closure’s already-bound arguments) of the pattern against the input string, starting at the intermediate state given by its State argument. If the match succeeds, the continuation returns the final State that it reached; if the match fails, the continuation returns `failure`.

A `Matcher` function is an internal closure that takes two arguments -- a State and a `Continuation` -- and returns a `MatchResult` result. The matcher attempts to match a middle subpattern (specified by the closure’s already-bound arguments) of the pattern against the input string, starting at the intermediate state given by its State argument. The Continuation argument should be a closure that matches the rest of the pattern. After matching the subpattern of a pattern to obtain a new State, the matcher then calls `Continuation` on that state to test if the rest of the pattern can match as well. If it can, the matcher returns the state returned by the continuation; if not, the matcher may try different choices at its choice points, repeatedly calling `Continuation` until it either succeeds or all possibilities have been exhausted.

An `AssertionTester` function is an internal closure that takes a State argument and returns a boolean result. The assertion tester tests a specific condition (specified by the closure's already-bound arguments) against the current place in the input string and returns `true` if the condition matched or `false` if not.

An `EscapeValue` is either a character or an integer. An `EscapeValue` is used to denote the interpretation of a `DecimalEscape` escape sequence: a character `ch` means that the escape sequence is interpreted as the character `ch`, while an integer `n` means that the escape sequence is interpreted as a backreference to the `n`th set of capturing parentheses.

### 15.10.2.2 Pattern

The production `Pattern :: Disjunction` evaluates as follows:

1. Evaluate `Disjunction` to obtain a Matcher `m`.
2. Return an internal closure that takes two arguments, a string `str` and an integer `index`, and performs the following:
   1. Let `Input` be the given string `str`. This variable will be used throughout the functions in 15.10.2.
   2. Let `InputLength` be the length of `Input`. This variable will be used throughout the functions in 15.10.2.
   3. Let `c` be a Continuation that always returns its State argument as a successful `MatchResult`.
   4. Let `cap` be an internal array of `NcapturingParens undefined` values, indexed 1 through `NcapturingParens`.
   5. Let `x` be the State (`index`, `cap`).
   6. Call `m(x, c)` and return its result.

**Informative comments:** A `Pattern` evaluates ("compiles") to an internal function value. `RegExp.prototype.exec` can then apply this function to a string and an offset within the string to determine whether the pattern would match starting at exactly that offset within the string, and, if it does match, what the values of the capturing parentheses would be. The algorithms in 15.10.2 are designed so that compiling a pattern may throw a `SyntaxError` exception; on the other hand, once the pattern is successfully compiled, applying its result function to find a match in a string cannot throw an exception (except for any host-defined exceptions that can occur anywhere such as out-of-memory).

### 15.10.2.3 Disjunction

The production `Disjunction :: Alternative` evaluates by evaluating `Alternative` to obtain a Matcher and returning that Matcher.

The production `Disjunction :: Alternative | Disjunction` evaluates as follows:

1. Evaluate `Alternative` to obtain a Matcher `m1`.
2. Evaluate `Disjunction` to obtain a Matcher `m2`.  

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3. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following:
   1. Call \( m1(x, c) \) and let \( r \) be its result.
   2. If \( r \) isn't \texttt{failure}, return \( r \).
   3. Call \( m2(x, c) \) and return its result.

**Informative comments:** The | regular expression operator separates two alternatives. The pattern first tries to match the left Alternative (followed by the sequel of the regular expression); if it fails, it tries to match the right Disjunction (followed by the sequel of the regular expression). If the left Alternative, the right Disjunction, and the sequel all have choice points, all choices in the sequel are tried before moving on to the next choice in the left Alternative. If choices in the left Alternative are exhausted, the right Disjunction is tried instead of the left Alternative. Any capturing parentheses inside a portion of the pattern skipped by | produce \texttt{undefined} values instead of strings. Thus, for example,

\[
/a|ab/.\texttt{exec(}"abc")
\]

returns the result "a" and not "ab". Moreover,

\[
/( (a) | (ab)) \{ (c) | (bc) \} /\texttt{exec(}"abc")
\]

returns the array

\[
["abc", "a", "a", \texttt{undefined}, "bc", \texttt{undefined}, "bc"]
\]

and not

\[
["abc", "ab", \texttt{undefined}, "ab", "c", "c", \texttt{undefined}]
\]

15.10.2.4 Alternative

The production \texttt{Alternative} :: \texttt{[empty]} evaluates by returning a Matcher that takes two arguments, a State \( x \) and a Continuation \( c \), and returns the result of calling \( c(x) \).

The production \texttt{Alternative} :: \texttt{Alternative Term} evaluates as follows:

1. Evaluate \texttt{Alternative} to obtain a Matcher \( m1 \).
2. Evaluate \texttt{Term} to obtain a Matcher \( m2 \).
3. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following:
   1. Create a Continuation \( d \) that takes a State argument \( y \) and returns the result of calling \( m2(y, c) \).
   2. Call \( m1(x, d) \) and return its result.

**Informative comments:** Consecutive Terms try to simultaneously match consecutive portions of the input string. If the left Alternative, the right Term, and the sequel of the regular expression all have choice points, all choices in the sequel are tried before moving on to the next choice in the right Term, and all choices in the right Term are tried before moving on to the next choice in the left Alternative.

15.10.2.5 Term

The production \texttt{Term} :: \texttt{Assertion} evaluates by returning an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following:

1. Evaluate \texttt{Assertion} to obtain an AssertionTester \( t \).
2. Call \( t(x) \) and let \( r \) be the resulting boolean value.
3. If \( r \) is \texttt{false}, return \texttt{failure}.
4. Call \( c(x) \) and return its result.

The production \texttt{Term} :: \texttt{Atom} evaluates by evaluating \texttt{Atom} to obtain a Matcher and returning that Matcher.

The production \texttt{Term} :: \texttt{Atom Quantifier} evaluates as follows:

1. Evaluate \texttt{Atom} to obtain a Matcher \( m \).
2. Evaluate \texttt{Quantifier} to obtain the three results: an integer \( \texttt{min} \), an integer (or \( \texttt{Infinity} \) \( \texttt{max} \), and boolean \texttt{greedy}.
3. If $\text{max}$ is finite and less than $\text{min}$, then throw a `SyntaxError` exception.
4. Let $\text{parenIndex}$ be the number of left capturing parentheses in the entire regular expression that occur to the left of this production expansion's `Term`. This is the total number of times the `Atom` :: ( `Disjunction` ) production is expanded prior to this production's `Term` plus the total number of `Atom` :: ( `Disjunction` ) productions enclosing this `Term`.
5. Let $\text{parenCount}$ be the number of left capturing parentheses in the expansion of this production's `Atom`. This is the total number of `Atom` :: ( `Disjunction` ) productions enclosed by this production's `Atom`.
6. Return an internal Matcher closure that takes two arguments, a State $x$ and a Continuation $c$, and performs the following:
   1. Call `RepeatMatcher(m, min, max, greedy, x, c, parenIndex, parenCount)` and return its result.

The abstract operation `RepeatMatcher` takes eight parameters, a Matcher $m$, an integer $\text{min}$, an integer (or $\infty$) $\text{max}$, a boolean $\text{greedy}$, a State $x$, a Continuation $c$, an integer $\text{parenIndex}$, and an integer $\text{parenCount}$, and performs the following:
1. If $\text{max}$ is zero, then call $c(x)$ and return its result.
2. Create an internal Continuation closure $d$ that takes one State argument $y$ and performs the following:
   - If $\text{min}$ is zero and $y$'s $\text{endIndex}$ is equal to $x$'s $\text{endIndex}$, then return `failure`.
   - If $\text{min}$ is zero then let $\text{min2}$ be zero; otherwise let $\text{min2}$ be $\text{min}$–1.
   - If $\text{max}$ is $\infty$, then let $\text{max2}$ be $\infty$; otherwise let $\text{max2}$ be $\text{max}$–1.
   - Call `RepeatMatcher(m, min2, max2, greedy, y, c, parenIndex, parenCount)` and return its result.
3. Let $\text{cap}$ be a fresh copy of $x$'s $\text{captures}$ internal array.
4. For every integer $k$ that satisfies $\text{parenIndex} < k$ and $k \leq \text{parenIndex}+\text{parenCount}$, set $\text{cap}[k]$ to `undefined`.
5. Let $e$ be $x$'s $\text{endIndex}$.
6. Let $\text{xr}$ be the State ($e$, $\text{cap}$).
7. If $\text{min}$ is not zero, then call $m(\text{xr}, d)$ and return its result.
8. If $\text{greedy}$ is `true`, then go to step 12.
9. Call $c(x)$ and let $z$ be its result.
10. If $z$ is not `failure`, return $z$.
11. Call $m(\text{xr}, d)$ and return its result.
12. Call $m(\text{xr}, d)$ and let $z$ be its result.
13. If $z$ is not `failure`, return $z$.
14. Call $c(x)$ and return its result.

**Informative comments:** An `Atom` followed by a `Quantifier` is repeated the number of times specified by the `Quantifier`. A quantifier can be non-greedy, in which case the `Atom` pattern is repeated as few times as possible while still matching the sequel, or it can be greedy, in which case the `Atom` pattern is repeated as many times as possible while still matching the sequel. The `Atom` pattern is repeated rather than the input string that it matches, so different repetitions of the `Atom` can match different input substrings.

If the `Atom` and the sequel of the regular expression all have choice points, the `Atom` is first matched as many (or as few, if non-greedy) times as possible. All choices in the sequel are tried before moving on to the next choice in the last repetition of `Atom`. All choices in the last ($n^{th}$) repetition of `Atom` are tried before moving on to the next choice in the next-to-last ($n$–1)’’ repetition of `Atom`; at which point it may turn out that more or fewer repetitions of `Atom` are now possible; these are exhausted (again, starting with either as few or as many as possible) before moving on to the next choice in the ($n$–1)’’ repetition of `Atom` and so on.

Compare

```
/a[a-z]{2,4}/.exec("abcdefghi")
```
which returns "abcdefghi"

with

```
/a[a-z]{2,4}/.exec("abcdeefghi")
```
which returns "abcde".

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Consider also

```
/(aa|aabaac|ba|b|c)/.exec("aabaac")
```

which, by the choice point ordering above, returns the array

```
["aaba", "ba"]
```

and not any of:

```
["aabaac", "aabaac"]
["aabaac", "c"]
```

The above ordering of choice points can be used to write a regular expression that calculates the greatest common divisor of two numbers (represented in unary notation). The following example calculates the gcd of 10 and 15:

```
"aaaaaaaaaa,aaaaaaaaaaaaaaa".replace(/^(a+).\1+$/,"\1")
```

which returns the gcd in unary notation "aaaaa".

Step 4 of the RepeatMatcher clears Atom's captures each time Atom is repeated. We can see its behaviour in the regular expression

```
/(z)((a+)?(b+)?(c))*/.exec("zaacbbbcac")
```

which returns the array

```
["zaacbbbcac", "z", "sc", "a", undefined, "c"]
```

and not

```
["zaacbbbcac", "z", "sc", "a", "bbb", "c"]
```

because each iteration of the outermost * clears all captured strings contained in the quantified Atom, which in this case includes capture strings numbered 2, 3, and 4.

Step 1 of the RepeatMatcher's closure d states that, once the minimum number of repetitions has been satisfied, any more expansions of Atom that match the empty string are not considered for further repetitions. This prevents the regular expression engine from falling into an infinite loop on patterns such as:

```
/(a*)*/.exec("b")
```

or the slightly more complicated:

```
/(a*)b\1+/.exec("baaaac")
```

which returns the array

```
["ba", ""]
```

15.10.2.6 Assertion

The production `Assertion :: ^` evaluates by returning an internal AssertionTester closure that takes a State argument \( x \) and performs the following:

1. Let \( e \) be \( x\)'s endIndex.
2. If \( e \) is zero, return `true`.
3. If `Multiline` is `false`, return `false`.
4. If the character `Input[e-1]` is one of `LineTerminator`, return `true`.
5. Return `false`.

The production `Assertion :: $` evaluates by returning an internal AssertionTester closure that takes a State argument \( x \) and performs the following:

1. Let \( e \) be \( x\)'s endIndex.
2. If \( e \) is equal to `InputLength`, return `true`.
3. If `Multiline` is `false`, return `false`.
4. If the character `Input[e]` is one of `LineTerminator`, return `true`.

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5. Return false.

The production Assertion :: \ b evaluates by returning an internal AssertionTester closure that takes a State argument \( x \) and performs the following:
1. Let \( e \) be \( x \)'s endIndex.
2. Call IsWordChar(e−1) and let \( a \) be the boolean result.
3. Call IsWordChar(e) and let \( b \) be the boolean result.
4. If \( a \) is true and \( b \) is false, return true.
5. If \( a \) is false and \( b \) is true, return true.
6. Return false.

The production Assertion :: B evaluates by returning an internal AssertionTester closure that takes a State argument \( x \) and performs the following:
1. Let \( e \) be \( x \)'s endIndex.
2. Call IsWordChar(e−1) and let \( a \) be the boolean result.
3. Call IsWordChar(e) and let \( b \) be the boolean result.
4. If \( a \) is true and \( b \) is false, return false.
5. If \( a \) is false and \( b \) is true, return false.
6. Return true.

The abstract operation IsWordChar takes an integer parameter \( e \) and performs the following:
1. If \( e == -1 \) or \( e == InputLength \), return false.
2. Let \( c \) be the character Input[e].
3. If \( c \) is one of the sixty-three characters in the table below, return true.

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

4. Return false.

15.10.2.7 Quantifier

The production Quantifier :: QuantifierPrefix evaluates as follows:
1. Evaluate QuantifierPrefix to obtain the two results: an integer \( min \) and an integer (or \( \infty \)) \( max \).
2. Return the three results \( min \), \( max \), and true.

The production Quantifier :: QuantifierPrefix ? evaluates as follows:
1. Evaluate QuantifierPrefix to obtain the two results: an integer \( min \) and an integer (or \( \infty \)) \( max \).
2. Return the three results \( min \), \( max \), and false.

The production QuantifierPrefix :: * evaluates by returning the two results 0 and \( \infty \).

The production QuantifierPrefix :: + evaluates by returning the two results 1 and \( \infty \).

The production QuantifierPrefix :: ? evaluates by returning the two results 0 and 1.

The production QuantifierPrefix :: { DecimalDigits } evaluates as follows:
1. Let \( i \) be the MV of DecimalDigits (see 7.8.3).
2. Return the two results \( i \) and \( i \).

The production QuantifierPrefix :: { DecimalDigits , } evaluates as follows:
1. Let \( i \) be the MV of DecimalDigits.
2. Return the two results \( i \) and \( \infty \).

The production QuantifierPrefix :: { DecimalDigits , DecimalDigits } evaluates as follows:
1. Let \( i \) be the MV of the first \( \text{DecimalDigits} \).
2. Let \( j \) be the MV of the second \( \text{DecimalDigits} \).
3. Return the two results \( i \) and \( j \).

15.10.2.8 Atom

The production \( \text{Atom} :: \text{PatternCharacter} \) evaluates as follows:
1. Let \( ch \) be the character represented by \( \text{PatternCharacter} \).
2. Let \( A \) be a one-element CharSet containing the character \( ch \).
3. Call \( \text{CharacterSetMatcher}(A, \text{false}) \) and return its Matcher result.

The production \( \text{Atom} :: . \) evaluates as follows:
1. Let \( A \) be the set of all characters except \( \text{LineTerminator} \).
2. Call \( \text{CharacterSetMatcher}(A, \text{false}) \) and return its Matcher result.

The production \( \text{Atom} :: \backslash \text{AtomEscape} \) evaluates by evaluating \( \text{AtomEscape} \) to obtain a Matcher and returning that Matcher.

The production \( \text{Atom} :: \text{CharacterClass} \) evaluates as follows:
1. Evaluate \( \text{CharacterClass} \) to obtain a CharSet \( A \) and a boolean \( \text{invert} \).
2. Call \( \text{CharacterSetMatcher}(A, \text{invert}) \) and return its Matcher result.

The production \( \text{Atom} :: \) \( ( \) \( \text{Disjunction} \) \) \( ) \) evaluates as follows:
1. Evaluate \( \text{Disjunction} \) to obtain a Matcher \( m \).
2. Let \( \text{parenIndex} \) be the number of left capturing parentheses in the entire regular expression that occur to the left of this production expansion’s initial left parenthesis. This is the total number of times the \( \text{Atom} :: \) \( ( \) \( \text{Disjunction} \) \) \( ) \) production is expanded prior to this production’s \( \text{Atom} :: \) \( ( \) \( \text{Disjunction} \) \) \( ) \) productions enclosing this \( \text{Atom} \).
3. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following:
   1. Create an internal Continuation closure \( d \) that takes one State argument \( y \) and performs the following:
      - Let \( cap \) be a fresh copy of \( y \)'s \( \text{captures} \) internal array.
      - Let \( xe \) be \( x \)'s \( \text{endIndex} \).
      - Let \( ye \) be \( y \)'s \( \text{endIndex} \).
      - Let \( s \) be a fresh string whose characters are the characters of \( \text{Input} \) at positions \( xe \) (inclusive) through \( ye \) (exclusive).
      - Set \( \text{cap}[\text{parenIndex}+1] \) to \( s \).
      - Let \( z \) be the State \( (xe, cap) \).
      - Call \( c(z) \) and return its result.
   2. Call \( m(x, d) \) and return its result.

The production \( \text{Atom} :: \) \( ? : \) \( \text{Disjunction} \) \) evaluates by evaluating \( \text{Disjunction} \) to obtain a Matcher and returning that Matcher.

The production \( \text{Atom} :: \) \( ? = \) \( \text{Disjunction} \) \) evaluates as follows:
1. Evaluate \( \text{Disjunction} \) to obtain a Matcher \( m \).
2. Return an internal Matcher closure that takes two arguments, a State \( x \) and a Continuation \( c \), and performs the following:
   1. Let \( d \) be a Continuation that always returns its State argument as a successful MatchResult.
   2. Call \( m(x, d) \) and let \( r \) be its result.
   3. If \( r \) is \( \text{failure} \), return \( \text{failure} \).
   4. Let \( y \) be \( r \)'s State.
   5. Let \( \text{cap} \) be \( y \)'s \( \text{captures} \) internal array.
   6. Let \( xe \) be \( x \)'s \( \text{endIndex} \).
   7. Let \( z \) be the State \( (xe, cap) \).
   8. Call \( c(z) \) and return its result.

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The production Atom :: ( ? ! Disjunction ) evaluates as follows:

1. Evaluate Disjunction to obtain a Matcher m.
2. Return an internal Matcher closure that takes two arguments, a State x and a Continuation c, and performs the following:
   1. Let d be a Continuation that always returns its State argument as a successful MatchResult.
   2. Call m(x, d) and let r be its result.
   3. If r isn't failure, return failure.
   4. Call c(x) and return its result.

The abstract operation CharacterSetMatcher takes two arguments, a CharSet A and a boolean flag invert, and performs the following:

1. Return an internal Matcher closure that takes two arguments, a State x and a Continuation c, and performs the following:
   1. Let e be x's endIndex.
   2. If e == InputLength, return failure.
   3. Let c be the character Input[e].
   4. Let cc be the result of Canonicalize(c).
   5. If invert is true, go to step 8.
   6. If there does not exist a member a of set A such that Canonicalize(a) == cc, then return failure.
   8. If there exists a member a of set A such that Canonicalize(a) == cc, then return failure.
   9. Let y be the State (e+1, cap).
   10. Let y be the State (x, cap).
   11. Call c(y) and return its result.

The abstract operation Canonicalize takes a character parameter ch and performs the following:

1. If IgnoreCase is false, return ch.
2. Let a be ch converted to upper case as if by calling the standard built-in method String.prototype.toUpperCase on the one-character string ch.
3. If a does not consist of a single character, return ch.
4. Let cu be a's character.
5. If ch's code point value is greater than or equal to decimal 128 and cu's code point value is less than decimal 128, then return ch.
6. Return cu.

Informative comments: Parentheses of the form ( Disjunction ) serve both to group the components of the Disjunction pattern together and to save the result of the match. The result can be used either in a backreference (\ followed by a nonzero decimal number), referenced in a replace string, or returned as part of an array from the regular expression matching function. To inhibit the capturing behaviour of parentheses, use the form (?: Disjunction ) instead.

The form (?= Disjunction ) specifies a zero-width positive lookahead. In order for it to succeed, the pattern inside Disjunction must match at the current position, but the current position is not advanced before matching the sequel. If Disjunction can match at the current position in several ways, only the first one is tried. Unlike other regular expression operators, there is no backtracking into a (?= form (this unusual behaviour is inherited from Perl). This only matters when the Disjunction contains capturing parentheses and the sequel of the pattern contains backreferences to those captures.

For example,

```javascript
/\(?=(a+)\)/ .exec("baaabac")
```

matches the empty string immediately after the first b and therefore returns the array:

```
["", "aaa"]
```

To illustrate the lack of backtracking into the lookahead, consider:

```javascript
/\(?=(a+)\)ab\1/.exec("baaabac")
```

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This expression returns

`["aba", "a"]`

and not:

`["aaaba", "a"]`

The form `(?! Disjunction)` specifies a zero-width negative lookahead. In order for it to succeed, the pattern inside `Disjunction` must fail to match at the current position. The current position is not advanced before matching the sequel. `Disjunction` can contain capturing parentheses, but backreferences to them only make sense from within `Disjunction` itself. Backreferences to these capturing parentheses from elsewhere in the pattern always return `undefined` because the negative lookahead must fail for the pattern to succeed. For example,

```
/(.*?)a(?!(a+)b)2c)/.exec("baaabaac")
```

looks for an `a` not immediately followed by some positive number `n` of `a`'s, a `b`, another `n` `a`'s (specified by the first `\2`) and a `c`. The second `\2` is outside the negative lookahead, so it matches against `undefined` and therefore always succeeds. The whole expression returns the array:

`["baaabaac", "ba", undefined, "abaac"]`

In case-insensitive matches all characters are implicitly converted to upper case immediately before they are compared. However, if converting a character to upper case would expand that character into more than one character (such as converting "ß" (`\u00DF`) into "SS"), then the character is left as-is instead. The character is also left as-is if it is not an ASCII character but converting it to upper case would make it into an ASCII character. This prevents Unicode characters such as `\u00F1` and `\u00E4` from matching regular expressions such as `/^[a-z]$/i`, which are only intended to match ASCII letters. Furthermore, if these conversions were allowed, then `/[^\W]/i` would match each of `a`, `b`, …, `h`, but not `i` or `s`.

15.10.2.9 AtomEscape

The production `AtomEscape :: DecimalEscape` evaluates as follows:

1. Evaluate `DecimalEscape` to obtain an `EscapeValue` `E`.
2. If `E` is not a character then go to step 6.
3. Let `ch` be `E`'s character.
4. Let `A` be a one-element CharSet containing the character `ch`.
5. Call `CharacterSetMatcher(A, false)` and return its Matcher result.
6. `E` must be an integer. Let `n` be that integer.
7. If `n=0` or `n>NCapturingParens` then throw a `SyntaxError` exception.
8. Return an internal Matcher closure that takes two arguments, a State `x` and a Continuation `c`, and performs the following:

   1. Let `cap` be `x`'s captures internal array.
   2. Let `s` be `cap[n]`.
   3. If `s` is `undefined`, then call `c(s)` and return its result.
   4. Let `e` be `s`'s endIndex.
   5. Let `len` be `s`'s length.
   6. Let `f` be `e+len`.
   7. If `f>InputLength`, return `failure`.
   8. If there exists an integer `i` between 0 (inclusive) and `len` (exclusive) such that `Canonicalize(s[i])` is not the same character as `Canonicalize(Input[e+i])`, then return `failure`.
9. Let `y` be the State (`f, cap`).
10. Call `c(y)` and return its result.

The production `AtomEscape :: CharacterEscape` evaluates as follows:

1. Evaluate `CharacterEscape` to obtain a character `ch`.
2. Let `A` be a one-element CharSet containing the character `ch`.
3. Call `CharacterSetMatcher(A, false)` and return its Matcher result.

The production `AtomEscape :: CharacterClassEscape` evaluates as follows:
1. Evaluate CharacterClassEscape to obtain a CharSet A.
2. Call CharacterSetMatcher(A, false) and return its Matcher result.

Informative comments: An escape sequence of the form \ followed by a nonzero decimal number n matches the result of the nth set of capturing parentheses (see 15.10.2.11). It is an error if the regular expression has fewer than n capturing parentheses. If the regular expression has n or more capturing parentheses but the nth one is undefined because it hasn't captured anything, then the backreference always succeeds.

15.10.2.10 CharacterEscape
The production CharacterEscape :: ControlEscape evaluates by returning the character according to the table below:

<table>
<thead>
<tr>
<th>ControlEscape</th>
<th>Unicode Value</th>
<th>Name</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>\u0009</td>
<td>horizontal tab</td>
<td>&lt;HT&gt;</td>
</tr>
<tr>
<td>n</td>
<td>\u000A</td>
<td>line feed (new line)</td>
<td>&lt;LF&gt;</td>
</tr>
<tr>
<td>v</td>
<td>\u000B</td>
<td>vertical tab</td>
<td>&lt;VT&gt;</td>
</tr>
<tr>
<td>f</td>
<td>\u000C</td>
<td>form feed</td>
<td>&lt;FF&gt;</td>
</tr>
<tr>
<td>r</td>
<td>\u000D</td>
<td>carriage return</td>
<td>&lt;CR&gt;</td>
</tr>
</tbody>
</table>

The production CharacterEscape :: c ControlLetter evaluates as follows:
1. Let ch be the character represented by ControlLetter.
2. Let i be ch's code point value.
3. Let j be the remainder of dividing i by 32.
4. Return the Unicode character numbered j.

The production CharacterEscape :: HexEscapeSequence evaluates by evaluating the CV of the HexEscapeSequence (see 7.8.4) and returning its character result.

The production CharacterEscape :: UnicodeEscapeSequence evaluates by evaluating the CV of the UnicodeEscapeSequence (see 7.8.4) and returning its character result.

The production CharacterEscape :: IdentityEscape evaluates by returning the character represented by IdentityEscape.

15.10.2.11 DecimalEscape
The production DecimalEscape :: DecimalIntegerLiteral [lookahead = DecimalDigit] evaluates as follows.
1. Let i be the MV of DecimalIntegerLiteral.
2. If i is zero, return the EscapeValue consisting of a <NUL> character (Unicode value 0000).
3. Return the EscapeValue consisting of the integer i.

The definition of “the MV of DecimalIntegerLiteral” is in 7.8.3.

Informative comments: If \ followed by a decimal number n whose first digit is not 0, then the escape sequence is considered to be a backreference. It is an error if n is greater than the total number of left capturing parentheses in the entire regular expression. \0 represents the NUL character and cannot be followed by a decimal digit.

15.10.2.12 CharacterClassEscape
The production CharacterClassEscape :: d evaluates by returning the ten-element set of characters containing the characters 0 through 9 inclusive.

The production CharacterClassEscape :: D evaluates by returning the set of all characters not included in the set returned by CharacterClassEscape :: d.

The production CharacterClassEscape :: a evaluates by returning the set of characters containing the characters that are on the right-hand side of the WhiteSpace (7.2) or LineTerminator (7.3) productions.

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The production `CharacterClassEscape :: $` evaluates by returning the set of all characters not included in the set returned by `CharacterClassEscape :: $`.

The production `CharacterClassEscape :: w` evaluates by returning the set of characters containing the sixty-three characters:

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

The production `CharacterClassEscape :: W` evaluates by returning the set of all characters not included in the set returned by `CharacterClassEscape :: w`.

**15.10.2.13 CharacterClass**

The production `CharacterClass :: [ lookahead { ^ } ClassRanges ]` evaluates by evaluating `ClassRanges` to obtain a CharSet and returning that CharSet and the boolean `false`.

The production `CharacterClass :: [ ^ ClassRanges ]` evaluates by evaluating `ClassRanges` to obtain a CharSet and returning that CharSet and the boolean `true`.

**15.10.2.14 ClassRanges**

The production `ClassRanges :: []` evaluates by returning the empty CharSet.

The production `ClassRanges :: NonemptyClassRanges` evaluates by evaluating `NonemptyClassRanges` to obtain a CharSet and returning that CharSet.

**15.10.2.15 NonemptyClassRanges**

The production `NonemptyClassRanges :: ClassAtom` evaluates by evaluating `ClassAtom` to obtain a CharSet and returning that CharSet.

The production `NonemptyClassRanges :: ClassAtom NonemptyClassRangesNoDash` evaluates as follows:

1. Evaluate `ClassAtom` to obtain a CharSet `A`.
2. Evaluate `NonemptyClassRangesNoDash` to obtain a CharSet `B`.
3. Return the union of CharSets `A` and `B`.

The production `NonemptyClassRangesNoDash :: ClassAtom - ClassAtom ClassRanges` evaluates as follows:

1. Evaluate the first `ClassAtom` to obtain a CharSet `A`.
2. Evaluate the second `ClassAtom` to obtain a CharSet `B`.
3. Evaluate `ClassRanges` to obtain a CharSet `C`.
4. Call `CharacterRange(A, B)` and let `D` be the resulting CharSet.
5. Return the union of CharSets `D` and `C`.

The **abstract operation** `CharacterRange` takes two CharSet parameters `A` and `B` and performs the following:

1. If `A` does not contain exactly one character or `B` does not contain exactly one character then throw a `SyntaxError` exception.
2. Let `a` be the one character in CharSet `A`.
3. Let `b` be the one character in CharSet `B`.
4. Let `i` be the code point value of character `a`.
5. Let `j` be the code point value of character `b`.
6. If `i > j` then throw a `SyntaxError` exception.
7. Return the set containing all characters numbered `i` through `j`, inclusive.

**15.10.2.16 NonemptyClassRangesNoDash**

The production `NonemptyClassRangesNoDash :: ClassAtom` evaluates by evaluating `ClassAtom` to obtain a CharSet and returning that CharSet.
The production `NonemptyClassRangesNoDash :: ClassAtomNoDash NonemptyClassRangesNoDash` evaluates as follows:
1. Evaluate `ClassAtomNoDash` to obtain a CharSet A.
2. Evaluate `NonemptyClassRangesNoDash` to obtain a CharSet B.
3. Return the union of CharSets A and B.

The production `NonemptyClassRangesNoDash :: ClassAtomNoDash - ClassAtom ClassRanges` evaluates as follows:
1. Evaluate `ClassAtomNoDash` to obtain a CharSet A.
2. Evaluate `ClassAtom` to obtain a CharSet B.
3. Evaluate `ClassRanges` to obtain a CharSet C.
4. Call `CharacterRange(A, B)` and let D be the resulting CharSet.
5. Return the union of CharSets D and C.

Informative comments: `ClassRanges` can expand into single `ClassAtoms` and/or ranges of two `ClassAtoms` separated by dashes. In the latter case the `ClassRanges` includes all characters between the first `ClassAtom` and the second `ClassAtom`, inclusive; an error occurs if either `ClassAtom` does not represent a single character (for example, if one is `\w`) or if the first `ClassAtom`'s code point value is greater than the second `ClassAtom`'s code point value.

Even if the pattern ignores case, the case of the two ends of a range is significant in determining which characters belong to the range. Thus, for example, the pattern `/[E-F]/i` matches only the letters E, F, e, and f, while the pattern `/[E-F]/i` matches all upper and lower-case ASCII letters as well as the symbols [], \, ^, _, and `.

A - character can be treated literally or it can denote a range. It is treated literally if it is the first or last character of `ClassRanges`, the beginning or end limit of a range specification, or immediately follows a range specification.

15.10.2.17 ClassAtom
The production `ClassAtom :: -` evaluates by returning the CharSet containing the one character `-`.

The production `ClassAtom :: ClassAtomNoDash` evaluates by evaluating `ClassAtomNoDash` to obtain a CharSet and returning that CharSet.

15.10.2.18 ClassAtomNoDash
The production `ClassAtomNoDash :: SourceCharacter but not one of \ `] -` evaluates by returning a one-element CharSet containing the character represented by `SourceCharacter`.

The production `ClassAtomNoDash :: \ ClassEscape` evaluates by evaluating `ClassEscape` to obtain a CharSet and returning that CharSet.

15.10.2.19 ClassEscape
The production `ClassEscape :: DecimalEscape` evaluates as follows:
1. Evaluate `DecimalEscape` to obtain an EscapeValue E.
2. If E is not a character then throw a `SyntaxError` exception.
3. Let ch be E's character.
4. Return the one-element CharSet containing the character ch.

The production `ClassEscape :: b` evaluates by returning the CharSet containing the one character <BS> (Unicode value 0008).

The production `ClassEscape :: CharacterEscape` evaluates by evaluating `CharacterEscape` to obtain a character and returning a one-element CharSet containing that character.

The production `ClassEscape :: CharacterClassEscape` evaluates by evaluating `CharacterClassEscape` to obtain a CharSet and returning that CharSet.

Informative comments: A `ClassAtom` can use any of the escape sequences that are allowed in the rest of the regular expression except for `\b`, `\B`, and backreferences. Inside a `CharacterClass`, `\b` means
15.10.3 The RegExp Constructor Called as a Function

15.10.3.1 RegExp(pattern, flags)

If pattern is an object R whose [[Class]] property is "RegExp" and flags is undefined, then return R unchanged. Otherwise call the standard built-in RegExp constructor (15.10.4.1), passing it the pattern and flags arguments and return the object constructed by that constructor.

15.10.4 The RegExp Constructor

When RegExp is called as part of a new expression, it is a constructor: it initialises the newly created object.

15.10.4.1 new RegExp(pattern, flags)

If pattern is an object R whose [[Class]] property is "RegExp" and flags is undefined, then let P be the pattern used to construct R and let F be the flags used to construct R. If pattern is an object R whose [[Class]] property is "RegExp" and flags is not undefined, then throw a TypeError exception. Otherwise, let F be the empty string if flags is undefined and ToString(flags) otherwise.

The global property of the newly constructed object is set to a Boolean value that is true if F contains the character "g" and false otherwise.

The ignoreCase property of the newly constructed object is set to a Boolean value that is true if F contains the character "i" and false otherwise.

The multiline property of the newly constructed object is set to a Boolean value that is true if F contains the character "m" and false otherwise.

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

The original RegExp prototype object, the one that is the initial value of RegExp.prototype.

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

15.10.5 Properties of the RegExp Constructor

The value of the internal [[Prototype]] property of the RegExp constructor is the Function prototype object (15.3.4).

Besides the internal properties and the length property (whose value is 2), the RegExp constructor has the following properties:

15.10.5.1 RegExp.prototype

The initial value of RegExp.prototype is the RegExp prototype object (15.10.6).

This property shall have the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false, }.
15.10.6 Properties of the RegExp Prototype Object

The value of the internal [[Prototype]] property of the RegExp prototype object is the Object prototype.
The RegExp prototype object is itself a regular expression object; its [[Class]] is "RegExp".

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

In the following descriptions of functions that are properties of the RegExp prototype object, the phrase "this RegExp object" refers to the object that is the `this` value for the invocation of the function; a `TypeError` exception is thrown if the `this` value is not an object for which the value of the internal [[Class]] property is "RegExp".

15.10.6.1 RegExp.prototype.constructor

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

15.10.6.2 RegExp.prototype.exec(string)

Performs a regular expression match of `string` against the regular expression and returns an Array object containing the results of the match, or `null` if the string did not match.

The string `ToString(string)` is searched for an occurrence of the regular expression pattern as follows:

1. Let `S` be the value of `ToString(string)`.
2. Let `length` be the length of `S`.
3. Let `lastIndex` be the value of the `lastIndex` property.
4. Let `i` be the value of `ToInteger(lastIndex)`.
5. If the `global` property is `false`, let `i = 0`.
6. If `I < 0` or `I > length` then set `lastIndex` to `0` and return `null`.
7. Call `[[Match]]`, giving it the arguments `S` and `i`.
   If `[[Match]]` returned `failure`, go to step 8;
   otherwise let `r` be its `State` result and go to step 10.
8. Let `i = i + 1`.
10. Let `e` be `r.endIndex` value.
11. If the `global` property is `true`, set `lastIndex` to `e`.
12. Let `n` be the length of `r.captures` array. (This is the same value as 15.10.2.1's `NCapturingParens`.)
13. Return a new array with the following properties:
   - The `index` property is set to the position of the matched substring within the complete string `S`.
   - The `input` property is set to `S`.
   - The `length` property is set to `n + 1`.
   - The `0` property is set to the matched substring (i.e. the portion of `S` between offset `i` inclusive and offset `e` exclusive).
   - For each integer `i` such that `I > 0` and `I ≤ n`, set the property named `ToString(i)` to the `i`th element of `r.captures` array.

15.10.6.3 RegExp.prototype.test(string)

Equivalent to the expression `RegExp.prototype.exec(string) != null`.

15.10.6.4 RegExp.prototype.toString()

Let `src` be a string in the form of a `Pattern` representing the current regular expression. `src` may or may not be identical to the `source` property or to the source code supplied to the RegExp constructor; however, if `src` were supplied to the RegExp constructor along with the current regular expression's flags, the resulting regular expression must behave identically to the current regular expression.

`toString` returns a string value formed by concatenating the strings "/", `src`, and "/"; plus "g" if the `global` property is `true`, "i" if the `ignoreCase` property is `true`, and "m" if the `multiline` property is `true`.

NOTE
An implementation may choose to take advantage of src being allowed to be different from the source passed to the RegExp constructor to escape special characters in src. For example, in the regular expression obtained from `new RegExp("/")`, src could be, among other possibilities, "/" or "\". The latter would permit the entire result ("/\") of the `toString` call to have the form `RegularExpressionLiteral`.

15.10.7 Properties of RegExp Instances

RegExp instances inherit properties from their [[Prototype]] object as specified above and also have the following properties.

15.10.7.1 source

The value of the `source` property is string in the form of a `Pattern` representing the current regular expression. This property shall have the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }`.

15.10.7.2 global

The value of the `global` property is a Boolean value indicating whether the flags contained the character "g". This property shall have the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }`.

15.10.7.3 ignoreCase

The value of the `ignoreCase` property is a Boolean value indicating whether the flags contained the character "i". This property shall have the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }`.

15.10.7.4 multiline

The value of the `multiline` property is a Boolean value indicating whether the flags contained the character "m". This property shall have the attributes `{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }`.

15.10.7.5 lastIndex

The value of the `lastIndex` property is an integer that specifies the string position at which to start the next match. This property shall have the attributes `{ [[Writable]]: true, [[Enumerable]]: false, [[Configurable]]: false }`.

15.11 Error Objects

Instances of Error objects are thrown as exceptions when runtime errors occur. The Error objects may also serve as base objects for user-defined exception classes.

15.11.1 The Error Constructor Called as a Function

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

15.11.1.1 Error (message)

The `[[Prototype]]` property of the newly constructed object is set to the original Error prototype object, the one that is the initial value of `Error.prototype` (15.11.3.1).

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

The `[[Extensible]]` property of the newly constructed object is set to `true`.

If the argument `message` is not `undefined`, the `message` property of the newly constructed object is set to `ToString(message)`. Otherwise, the `message` property is set to the empty string.

15.11.2 The Error Constructor

When `Error` is called as part of a `new` expression, it is a constructor: it initialises the newly created object.
15.11.2.1 new Error (message)
The [[Prototype]] property of the newly constructed object is set to the original Error prototype object, the one that is the initial value of Error.prototype (15.11.3.1).

The [[Class]] property of the newly constructed Error object is set to "Error".
The [[Extensible]] property of the newly constructed object is set to true.

If the argument message is not undefined, the message property of the newly constructed object is set to ToString(message).

15.11.3 Properties of the Error Constructor
The value of the internal [[Prototype]] property of the Error constructor is the Function prototype object (15.3.4).

Besides the internal properties and the length property (whose value is 1), the Error constructor has the following property:

15.11.3.1 Error.prototype
The initial value of Error.prototype is the Error prototype object (15.11.4).

This property has the attributes {
  [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false
}

15.11.4 Properties of the Error Prototype Object
The Error prototype object is itself an Error object (its [[Class]] is "Error").

The value of the internal [[Prototype]] property of the Error prototype object is the Object prototype object (15.2.3.1).

15.11.4.1 Error.prototype.constructor
The initial value of Error.prototype.constructor is the built-in Error constructor.

15.11.4.2 Error.prototype.name
The initial value of Error.prototype.name is "Error".

15.11.4.3 Error.prototype.message
The initial value of Error.prototype.message is an implementation-defined string.

15.11.4.4 Error.prototype.toString ()
Returns an implementation-defined string.

15.11.5 Properties of Error Instances
Error instances have no special properties beyond those inherited from the Error prototype object.

15.11.6 Native Error Types Used in This Standard
One of the NativeError objects below is thrown when a runtime error is detected. All of these objects share the same structure, as described in 15.11.7.

15.11.6.1 EvalError
Indicates that the global function eval was used in a way that is incompatible with its definition. See 15.1.2.1.

15.11.6.2 RangeError
Indicates a numeric value has exceeded the allowable range. See 15.4.2.2, 15.4.5.1, 15.7.4.5, 15.7.4.6, and 15.7.4.7.

15.11.6.3 ReferenceError
Indicate that an invalid reference value has been detected. See 8.7.1, and 8.7.2.

15.11.6.4 SyntaxError
Indicates that a parsing error has occurred. See 15.1.2.1, 15.3.2.1, 15.10.2.5, 15.10.2.9, 15.10.2.15, 15.10.2.19, and 15.10.4.1.
15.11.6.5 **TypeError**
Indicates the actual type of an operand is different than the expected type. See 8.6.2, 8.6.2.6, 9.9, 11.2.2, 11.2.3, 11.8.6, 11.8.7, 15.3.4.2, 15.3.4.3, 15.3.4.4, 15.3.5.3, 15.4.4.2, 15.4.4.3, 15.5.4.2, 15.5.4.3, 15.6.4, 15.6.4.2, 15.6.4.3, 15.7.4, 15.7.4.2, 15.7.4.4, 15.9.5, 15.9.5.9, 15.9.5.27, 15.10.4.1, and 15.10.6.

15.11.6.6 **URIError**
Indicates that one of the global URI handling functions was used in a way that is incompatible with its definition. See 15.1.3.

15.11.7 **NativeError Object Structure**
When an ECMAScript implementation detects a runtime error, it throws an instance of one of the `NativeError` objects defined in 15.11.6. Each of these objects has the structure described below, differing only in the name used as the constructor name instead of `NativeError`, in the `name` property of the prototype object, and in the implementation-defined `message` property of the prototype object.

For each error object, references to `NativeError` in the definition should be replaced with the appropriate error object name from 15.11.6.

15.11.7.1 **NativeError Constructors Called as Functions**
When a `NativeError` constructor is called as a function rather than as a constructor, it creates and initialises a new object. A call of the object as a function is equivalent to calling it as a constructor with the same arguments.

15.11.7.2 **NativeError (message)**
The `[[Prototype]]` property of the newly constructed object is set to the prototype object for this error constructor. The `[[Class]]` property of the newly constructed object is set to "`Error`". The `[[Extensible]]` property of the newly constructed object is set to `true`.

If the argument `message` is not `undefined`, the `message` property of the newly constructed object is set to `ToString(message)`.

15.11.7.3 **The NativeError Constructors**
When a `NativeError` constructor is called as part of a `new` expression, it is a constructor: it initialises the newly created object.

15.11.7.4 **New NativeError (message)**
The `[[Prototype]]` property of the newly constructed object is set to the prototype object for this `NativeError` constructor. The `[[Class]]` property of the newly constructed object is set to "`Error`". The `[[Extensible]]` property of the newly constructed object is set to `true`.

If the argument `message` is not `undefined`, the `message` property of the newly constructed object is set to `ToString(message)`.

15.11.7.5 **Properties of the NativeError Constructors**
The value of the internal `[[Prototype]]` property of a `NativeError` constructor is the Function prototype object (15.3.4).

Besides the internal properties and the `length` property (whose value is 1), each `NativeError` constructor has the following property:

15.11.7.6 **NativeError.prototype**
The initial value of `NativeError.prototype` is a `NativeError` prototype object (15.11.7.7). Each `NativeError` constructor has a separate prototype object.

This property has the attributes ([`Writable`]: `false`, `[Enumerable`]: `false`, `[Configurable`]: `false`).

15.11.7.7 **Properties of the NativeError Prototype Objects**
Each `NativeError` prototype object is an `Error` object (its `[[Class]]` is "`Error`").

The value of the internal `[[Prototype]]` property of each `NativeError` prototype object is the `Error` prototype object (15.11.4).
15.11.7.8 NativeError.prototype.constructor
The initial value of the constructor property of the prototype for a given NativeError constructor is the NativeError constructor function itself (15.11.7).

15.11.7.9 NativeError.prototype.name
The initial value of the name property of the prototype for a given NativeError constructor is the name of the constructor (the name used instead of NativeError).

15.11.7.10 NativeError.prototype.message
The initial value of the message property of the prototype for a given NativeError constructor is an implementation-defined string.

NOTE
The prototypes for the NativeError constructors do not themselves provide a toString function, but instances of errors will inherit it from the Error prototype object.

15.11.7.11 Properties of NativeError Instances
NativeError instances have no special properties beyond those inherited from the Error prototype object.

15.12 The JSON Object

The JSON object is a single object that contains two functions, parse and stringify, that are used to parse and construct JSON texts. The JSON Data Interchange Format is described in RFC 4627 <http://www.ietf.org/rfc/rfc4627.txt?number=4627>.

The value of the internal [[Prototype]] property of the JSON object is the Object prototype object (15.2.3.1). The value of the internal [[Class]] property of the JSON object is "JSON". The value of the [[Extensible]] property of the JSON object is set to true.

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

The JSON object does not have a [[Call]] property; it is not possible to invoke the JSON object as a function.

JSON.stringify produces a string that conforms to the following grammar. JSON.parse accepts a string that conform to the following grammar.

Comment [pl61]: From DEC:
Using Math as the model for the JSON object. I am not aware that [[Class]] is seen anywhere except in the useless text returned by object.toString. I see no harm in JSON being mutable. Caja can lock it down if it wants to.
JSONValue ::
  NullLiteral
  BooleanLiteral
  JSONObject
  JSONArray
  JSONString
  JSONNumber

JSONObject ::
  { } [ JSONMemberList ]

JSONMember ::
  JSONString : JSONValue

JSONMemberList ::
  JSONMember
  JSONMemberList , JSONMember

JSONArray ::
  [ ] [ JSONElementList ]

JSONElementList ::
  JSONValue
  JSONElementList , JSONValue

JSONString ::
  "JSONCharacters_opt"

JSONCharacters ::
  JSONCharacter JSONCharacters_opt

JSONCharacter ::
  Any Unicode character except U+0000 thru U+001F but not double-quote " or backslash \ 

JSONEscapeSequence ::
  JSONEscapeCharacter a HexDigit HexDigit HexDigit HexDigit

JSONEscapeCharacter ::
  one of "/\b\f\n\r\t"

JSONNumber ::
  JSONInteger JSONFraction_opt JSONExponent_opt

JSONInteger ::
  DecimalDigit
  JSONDigit DecimalDigits

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

JSONFraction ::
  . DecimalDigits

JSONExponent ::
  ExponentIndicator SignedInteger

15.12.1 parse ( text [ , reviver ] )

The parse function parses a JSON text (a JSON formatted string) and produces a ECMAScript value. The JSON format is a restricted form of ECMAScript literal. JSON objects are realized as ECMAScript objects. JSON Arrays are realized as ECMAScript arrays. JSON strings, numbers, booleans, and null are
realized as ECMAScript strings, numbers, booleans, and null. JSON uses a more limited set of white space characters than WhiteSpace.

The optional reviver parameter is a function that takes two parameters, (key, value). It can filter and transform the results. It is called with each of the key/value pairs produced by the parse, and its return value is used instead of the original value. If it returns undefined then the member is deleted from the result.

1. ToString of text.
2. Parse Result(1) as a JSON value. Throw a SyntaxError exception if the text did not conform to the JSON grammar for JSON values. JSON objects will produce objects as if made by the original Object constructor. JSON arrays will produce arrays as if made by the original Array constructor. JSON numbers will produce number values. JSON strings will produce string values. JSON true, false, and null will produce the true, false, and null values. No other values are possible.
3. If IsCallable(reviver) is true
   a. Produce a new object as if by the original Object constructor.
   b. Call the [[Put]] method of Result(3.a) with an empty string and Result(2).
   c. Call the abstract operation walk, passing Result(3.b) and the empty string. The abstract operation walk is described below.
   d. Return Result(3.c).
4. Else
   a. Return Result(2).

The abstract operation walk is a recursive abstract operation that takes two parameters: a holder object and the name of a property in that object.

1. Call the [[Get]] method of the holder with name.
2. If Result(1) is an object, and IsCallable(Result(1)) is false, then
   a. If the [[Class]] property of Result(1) is "Array"
      i. Set I to 0.
      ii. While I is less than then length of Result(1)
          1. Call the internal walk function, passing Result(1) and I.
          2. Call the [[Put]] method of Result(1) with Result(2.a.ii.1).
          3. Add 1 to I.
   b. Else
      i. Produce an array using the original Object.keys method with Result(1) and true.
      ii. For each element in Result(2.b.1)
          1. Call the internal walk function, passing Result(1) and Result(2.b.ii).
          2. If Result(2.b.ii.1) is undefined
             a. Call the [[Delete]] method of Result(1) with Result(2.b.ii).
          3. Else
             a. Call the [[Put]] method of Result(1) with Result(2.b.ii.1).
   3. Call reviver as a method of holder with name and Result(1).
   4. Return Result(3).

NOTE: In the case where there are duplicate name strings within an object, lexically preceding values for the same key shall be overwritten.

15.12.2 stringify ( value [ , replacer [ , space ] ] )

The stringify function produces a JSON formatted string that captures information from a JavaScript value. It can take three parameters. The first parameter is required. The value parameter is a JavaScript value is usually an object or array, although it can also be a string, boolean, number or null. The optional replacer parameter is either a function that alters the way objects and arrays are stringified, or an array of strings that acts as a whitelist for selecting the keys that will be stringified. The optional space parameter is a string or number that allows the result to have white space injected into it to improve human readability.

JSON structures are allowed to be nested to any depth, but they must be acyclic. If the value is a cyclic structure, then the stringify function must throw an Error. This is an example of a value that cannot be stringified:

```javascript
a = [];`
a[0] = a;
my_text = JSON.stringify(a); // This must throw an Error.

The null value is rendered in JSON text as the string null.
The true value is rendered in JSON text as the string true.
The false value is rendered in JSON text as the string false.

String values are wrapped in double quotes. The characters " and \ are escaped with \ prefixes. Control characters are replaced with escape sequences \uHHHH, or with the shorter forms, \b (backspace), \f (formfeed), \n (newline), \r (carriage return), \t (tab).

Finite numbers are stringifyed by String(number). NaN and Infinity regardless of sign are represented as the string null.

Values that do not have a JSON representation (such as undefined and functions) do not produce a string. Instead they produce the undefined value. In arrays these values are represented as the string null. In objects an unrepresentable value causes the property to be excluded from stringification.

An object is rendered as an opening left brace followed by zero or more properties, separated with commas, closed with a right brace. A property is a quoted string representing the key or property name, a colon, and then the stringified property value. An array is rendered as an opening left bracket followed by zero or more values, separated with commas, closed with a right bracket.

These are the steps in stringifying an object:
1. Create a new array by the original Array method.
2. Let stack be Result(1).
3. Let indent be the empty string.
4. If space is a number
   a. Set gap to a string containing space space characters. This will be the empty string if space is less than 1.
5. Else If space is a string
   a. Set gap to space.
6. Else
   a. Set gap to the empty string.
7. Create a new Object by the original Object method.
8. Call the [[Put]] method of Result(7) with the empty string and value.
9. Call the abstract operation str with the empty string and Result(7).
10. Return Result(9).

The internal abstract operation str(key, holder) has access to the replacer from the invocation of the stringify method. Its algorithm is as follows:
1. Call the [[Get]] method of holder with key.
2. Let value be Result(1).
3. If value is an object
   a. Call the [[Get]] method on value with "toJSON".
   b. If IsCallable(Result(3.a)) is true
      i. Call Result(3.a) as a method of value with key.
      ii. Let value be Result(3.b.i).
4. If IsCallable(replacer) is true
   a. Call replacer as a method of holder with key and value.
   b. Let value be Result(4.a).
5. If value is null then return "null".
6. If value is true then return "true".
7. If value is false then return "false".
8. If value is a string, then return the result of calling the abstract operation Quote with value.
9. If value is a number
   a. If value is finite then return value.
   b. Return "null".
10. If value is an object, and IsCallable(value) is false
    a. If the [[Class]] property of value is "Array" then
i. Call the abstract operation JA with value.
ii. Return Result(10.a.1).
b. Call the abstract operation JO with value.
c. Return Result(10.b).

1. Return undefined.

The abstract operation Quote(value) wraps a string value in double quotes and escapes characters within it.

1. Let product be the double quote character.
2. For each character in value
   a. If Result(2) is the double quote character or backslash character
      i. Let product be the concatenation of product and the backslash character.
      ii. Let product be the concatenation of product and Result(2).
   b. Else If Result(2) is backspace, formfeed, newline, carriage return, or tab
      i. Let product be the concatenation of product and the backslash character.
      ii. Let product be the concatenation of product and the lowercase letter b, f, n, r, or t.
   c. Else If Result(2) is a control character having a value less than the space character
      i. Let product be the concatenation of product and the backslash character.
      ii. Let product be the concatenation of product and the lowercase u character.
      iii. Convert the numeric value of Result(2) to a string of 4 base 16 digits.
      iv. Let product be the concatenation of product and Result(2.c.3).
   d. Else
      i. Let product be the concatenation of product and Result(2).
3. Let product be the concatenation of product and the double quote character.
4. Return product.

The abstract operation JO(value) serializes an object. It has access to the stack, indent, gap, replacer, and space of the invocation of the stringify method.

1. Call the original indexOf method on stack with value.
2. If Result(1) is not -1 then throw an Error because the structure is cyclical.
3. Push value onto stack.
4. Let stepback be indent.
5. Let indent be the concatenation of indent and gap.
6. If the [[Class]] property of replacer is "Array"
   a. Let K be the replacer parameter.
   b. Else
      a. Call the original Object.keys method with value and true.
      b. Let K be Result(6.a).
6. Create a new array by the original Array method.
7. Let partial be Result(8).
8. For each element of K:
   a. Call the str function with Result(10) and value.
   b. If Result(10.a) is not undefined
      i. Call Quote with Result(10).
      ii. Let member be Result(10.b.i).
      iii. Let member be the concatenation of member and the colon character.
      iv. If gap is not empty string
          i. Let member be the concatenation of member and the space character.
          v. Else
             i. Let member be the concatenation of member and the Result(10.a).
             ii. Push Result(10.b.v) onto partial.
8. If Length(partial) is 0 then
   a. Let final be "{".
12. Else
   a. If gap is the empty string
      i. Call the original join method of partial with the comma character.
      ii. Concatenate "{" and Result(12.a.i) and "}".
      iii. Set final to Result(12.a.ii).
   b. Else

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The abstract operation \( JA(\text{value}) \) serializes an array. It has access to the \( \text{stack} \), \( \text{indent} \), \( \text{gap} \), and \( \text{space} \) of the invocation of the stringify method. The representation of arrays includes only the elements between zero and \( \text{array.length} - 1 \). Named properties are excluded from the stringification. An array is stringified as an open left bracket, elements separated by comma, and a closing right bracket.

1. Call the original \( \text{indexOf} \) method on \( \text{stack} \) with \( \text{value} \).
2. If \( \text{Result}(1) \) is not -1 then throw an Error because the structure is cyclical.
3. Push \( \text{value} \) onto \( \text{stack} \).
4. Let \( \text{stepback} \) be \( \text{indent} \).
5. Let \( \text{indent} \) be the concatenation of \( \text{indent} \) and \( \text{gap} \).
6. Create a new array by the original \( \text{Array} \) method.
7. Let \( \text{partial} \) be \( \text{Result}(6) \).
8. For each \( \text{index} \) in \( \text{value} \).
   a. Call the \( \text{str} \) function with \( \text{Result}(8) \) and \( \text{value} \).
   b. If \( \text{Result}(8.a) \) is \( \text{undefined} \)
      i. Push \( \text{null} \) on \( \text{partial} \).
   c. Else
      i. Push \( \text{Result}(8.a) \).
9. If \( \text{Length}(\text{partial}) \) is 0 then
   a. Let \( \text{final} \) be “[”.
10. Else
   a. If \( \text{gap} \) is the empty string
      i. Call the original \( \text{join} \) method of \( \text{partial} \) with the comma character.
   b. Else
      i. Concatenate the comma character and \( \text{indent} \).
   c. Call the original \( \text{join} \) method of \( \text{partial} \) with \( \text{Result}(12.b.i) \).
   d. Concatenate “[” and \( \text{Result}(12.b.ii) \) and the line feed character and \( \text{stepback} \) and “]”.
iv. Set \( \text{final} \) to \( \text{Result}(12.b.iii) \).
11. Pop the \( \text{stack} \).
12. Let \( \text{indent} \) be \( \text{stepback} \).
13. Return \( \text{final} \).

15.13 Decimal

15.13.1 Overview of Decimal Objects and Definitions of Internal Operators
A Decimal object contains an IEEE 754r decimal-encoded 34-digit floating point number.

15.13.1.1 UnscaledValue
A 34 digit integer, stored exactly.

15.13.1.2 Scale
The number of digits to the right of the decimal point. If negative, the unscaled value of the number is multiplied by ten to the power of the negation of the scale.

15.13.1.3 Value
The value formed by computing UnscaledValue * (10**Scale).

15.13.2 The Decimal Constructor Called as a Function
When Decimal is called as a function rather than as a constructor, it performs a type conversion.
15.13.1 Decimal ( [ value ] )

Returns a decimal value (not a Decimal object) computed by ToDecimal(value) if value was supplied, else returns +0.

15.13.3 The Decimal Constructor

When Decimal is called as part of a `new` expression it is a constructor: it initialises the newly created object.

15.13.3.1 new Decimal ( [ 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 Decimal.prototype (15.7.3.1).

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

The `[[PrimitiveValue]]` property of the newly constructed object is set to ToDecimal(value) if value was supplied, else to +0.

The `[[Extensible]]` property of the newly constructed object is set to `false`.

15.13.4 Properties of the Decimal constructor

The value of the internal `[[Prototype]]` property of the Decimal constructor is the Function prototype object (15.3.4).

Besides the internal properties and the `length` property (whose value is 1), the Decimal constructor has the following properties:

15.13.4.1 Decimal.CEILING

Rounding mode to round towards positive infinity.

Value is the number 2

15.13.4.2 Decimal.DOWN

Rounding mode to round towards zero.

Value is the number 1.

15.13.4.3 Decimal.FLOOR

Rounding mode to round towards negative infinity.

Value is the number 3.

15.13.4.4 Decimal.HALF_DOWN

Rounding mode to round towards "nearest neighbour" unless both neighbours are equidistant, in which case round down.

Value is the number 5.

15.13.4.5 Decimal.HALF_EVEN

Rounding mode to round towards the "nearest neighbour" unless both neighbours are equidistant, in which case, round towards the even neighbour.

Value is the number 6.

15.13.4.6 Decimal.HALF_UP

Rounding mode to round towards "nearest neighbour" unless both neighbours are equidistant, in which case round up.

Value is the number 4.

15.13.4.7 Decimal.UP

Rounding mode to round away from zero.

Value is the number 0.

15.13.4.8 Decimal.Infinity

The primitive value Infinity represents the set of IEEE 754-2008 positive infinite number values.
15.13.4.9 Decimal.NaN

The primitive value NaN represents that set of IEEE 754-2008 Standard “Not-a-Number” values. This value is a member of the Decimal type.

15.13.4.10 Decimal.prototype

The initial value of Decimal.prototype is the Decimal prototype object. This property has the attributes

{ [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

15.13.4.11 Decimal.abs ( x )

Returns the absolute value of x; the result has the same magnitude as x but has positive sign.

- If x is NaN, the result is NaN.
- If x is −0, the result is +0.
- If x is −∞, the result is +∞.

15.13.4.12 Decimal.divideInteger ( x, y, context )

Returns the integer portion of the division of x by y, with rounding specified by the context.

15.13.4.13 Decimal.max ( [ value1 [, value2 [, ... ] ] ] )

Given zero or more arguments, calls ToDecimal on each of the arguments and returns the largest of the resulting values.

- If no arguments are given, the result is −∞.
- If any value is NaN, the result is NaN.

The comparison of values to determine the largest value is done as in 11.8.5 except that +0 is considered to be larger than −0.

The length property of the max method is 2.

15.13.4.14 Decimal.min ( [ value1 [, value2 [, ... ] ] ] )

Given zero or more arguments, calls ToDecimal on each of the arguments and returns the smallest of the resulting values.

- If no arguments are given, the result is +∞.
- If any value is NaN, the result is NaN.

The comparison of values to determine the smallest value is done as in 11.8.5 except that +0 is considered to be larger than −0.

15.13.4.15 Decimal.rescale ( value, fractionDigits, roundingMode )

Return value with the exponent set to the negative of value of fractionDigits, with rounding to be done in accordance to the roundingMode specified. roundingMode is an integer from 0 to 6, and interpreted as per the corresponding Decimal constructor constant definition. Any other value than an integer from 0 to 6 causes a RangeError exception to be thrown.

15.13.5 Properties of the Decimal Prototype Object

The Decimal prototype object is itself a Decimal object (its [[Class]] is “Decimal”).

The value of the internal [[Prototype]] property of the Decimal prototype object is the Object prototype object (15.2.3.1).

15.13.5.1 Decimal.prototype.constructor

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

15.13.5.2 Decimal.prototype.name

The initial value of Decimal.prototype.name is “Decimal”.

15.13.5.4 Decimal.prototype.toString ( )

1. If the value is NaN, return ‘NaN’
2. If the value is Infinity, return ‘Infinity’
3. If the value is Zero, return ‘0’
4. Convert the coefficient to a string in base 10 using the characters 0 through 9 with no leading zeros.

5. Compute the exponent, plus the number of characters in the converted coefficient, less one. That
is, exponent+(clength-1), where clength is the length of the coefficient in decimal digits.

6. If the exponent is less than or equal to zero and the Result(5) is greater than or equal to -6, the
number will be converted to a character form without using exponential notation. In this case, if
the exponent is zero then no decimal point is added. Otherwise (the exponent will be negative), a
decimal point will be inserted with the absolute value of the exponent specifying the number of
characters to the right of the decimal point. '0' characters are added to the left of the converted
coefficient as necessary. If no character precedes the decimal point after this insertion then a
conventional '0' character is prefixed.

7. Otherwise (that is, if the exponent is positive, or the Result(5) is less than -6), the number will be
converted to a character form using exponential notation. In this case, if the converted coefficient
has more than one digit a decimal point is inserted after the first digit. An exponent in character
form is then suffixed to the converted coefficient (perhaps with inserted decimal point); this
comprises the letter ‘E’ followed immediately by the Result(5) converted to a character form. The
latter is in base ten, using the characters 0 through 9 with no leading zeros, always prefixed by a
sign character (‘-‘ if the calculated exponent is negative,’+‘ otherwise).

8. In all cases, the entire string is prefixed by a minus sign character (‘-‘) if this.signum() is -1. No
sign character is prefixed if this.signum() is 0 or 1.

15.13.5.5 Decimal.prototype.toEngineeringString ( )
Returns a string representation of this Decimal, using engineering notation if an exponent is needed.

Returns a string that represents the Decimal as described in the toString() method, except that if
exponential notation is used, the power of ten is adjusted to be a multiple of three (engineering
notation) such that the integer part of nonzero values will be in the range 1 through 999. If exponential
notation is used for zero values, a decimal point and one or two fractional zero digits are used so that
the scale of the zero value is preserved. Note that unlike the output of toString(), the output of this
method is not guaranteed to recover the same scale() and unscaledValue() of this Decimal if the output
string is converting back to a Decimal using the string constructor. The result of this method meets the
weaker constraint of always producing a numerically equal result from applying the string constructor
to the method’s output.

15.13.6 Properties of Decimal Instances

Decimal instances have no special properties beyond those inherited from the Decimal prototype
object.
16 Errors

An implementation should report runtime errors at the time the relevant language construct is evaluated. An implementation may report syntax errors in the program at the time the program is read in, or it may, at its option, defer reporting syntax errors until the relevant statement is reached. An implementation may report syntax errors in `eval` code at the time `eval` is called, or it may, at its option, defer reporting syntax errors until the relevant statement is reached.

An implementation may treat any instance of the following kinds of runtime errors as a syntax error and therefore report it early:

- Improper uses of `return`, `break`, and `continue`.
- Using the `eval` property other than via a direct call.
- Errors in regular expression literals.
- Attempts to call `PutValue` on a value that is not a reference (for example, executing the assignment statement `3=4`).

An implementation shall not report other kinds of runtime errors early even if the compiler can prove that a construct cannot execute without error under any circumstances. An implementation may issue an early warning in such a case, but it should not report the error until the relevant construct is actually executed.

An implementation shall report all errors as specified, except for the following:

- An implementation may extend program and regular expression syntax. To permit this, all operations (such as calling `eval`, using a regular expression literal, or using the `Function` or `RegExp` constructor) that are allowed to throw `SyntaxError` are permitted to exhibit implementation-defined behaviour instead of throwing `SyntaxError` when they encounter an implementation-defined extension to the program or regular expression syntax.

- An implementation may provide additional types, values, objects, properties, and functions beyond those described in this specification. This may cause constructs (such as looking up a variable in the global scope) to have implementation-defined behaviour instead of throwing an error (such as `ReferenceError`).

- An implementation is not required to detect `EvalError`. If it chooses not to detect `EvalError`, the implementation must allow `eval` to be used indirectly and/or allow assignments to `eval`.

- An implementation may define behaviour other than throwing `RangeError` for `toFixed`, `toExponential`, and `toPrecision` when the `fractionDigits` or `precision` argument is outside the specified range.

Comment [pl62]: From AWB:
May need to update this list.
Annex A
(informative)

Grammar Summary

A.1 Lexical Grammar

SourceCharacter ::
  any Unicode character

See clause 6

InputElementDiv ::
 WhiteSpace
  LineTerminator
  Comment
  Token
  DivPunctuator

See clause 7

InputElementRegExp ::
 WhiteSpace
  LineTerminator
  Comment
  Token
  RegularExpressionLiteral

See clause 7

WhiteSpace ::
  <TAB>
  <VT>
  <FF>
  <SP>
  <NEL>
  <NBSP>
  <ZWSP>
  <BOM>
  <USP>

Deleted: 6

LineTerminator ::
  <LF>
  <CR>
  <LS>
  <PS>
  <CR> <LF>

Comment ::
  MultiLineComment
  SingleLineComment

Deleted: 6

MultiLineComment ::
  /* MultiLineCommentChars opt */
MultiLineCommentChars ::
  MultiLineNotAsteriskChar MultiLineCommentChars
  * PostAsteriskCommentChars

PostAsteriskCommentChars ::
  MultiLineNotForwardSlashOrAsteriskChar MultiLineCommentChars
  * PostAsteriskCommentChars

MultiLineNotAsteriskChar ::
  SourceCharacter but not asterisk *

MultiLineNotForwardSlashOrAsteriskChar ::
  SourceCharacter but not forward-slash / or asterisk *

SingleLineComment ::
  // SingleLineCommentChars

SingleLineCommentChars ::
  SingleLineCommentChar SingleLineCommentChars

SingleLineCommentChar ::
  SourceCharacter but not LineTerminator

Token ::
  ReservedWord
  Identifier
  Punctuator
  NumericLiteral
  StringLiteral

ReservedWord ::
  Keyword
  FutureReservedWord
  NullLiteral
  BooleanLiteral

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

FutureReservedWord :: one of
  abstract  enum  int  short
  boolean  export  interface  static
  byte  extends  long  super
  char  final  native  synchronized

- 188 -
class float package throws
goto private transient
implements protected volatile
double import public

Identifier ::
  IdentifierName but not ReservedWord

IdentifierName ::
  IdentifierStart

IdentifierStart ::
  UnicodeLetter
  $
  UnicodeEscapeSequence

IdentifierPart ::
  IdentifierStart
  UnicodeCombiningMark
  UnicodeDigit
  UnicodeConnectorPunctuation
  UnicodeEscapeSequence

UnicodeLetter ::
  any character in the Unicode categories “Uppercase letter (Lu)”, “Lowercase letter (Ll)”, “Titlecase letter (Lt)”, “Modifier letter (Lm)”, “Other letter (Lo)”, or “Letter number (Nl)”.

UnicodeCombiningMark ::
  any character in the Unicode categories “Non-spacing mark (Mn)” or “Combining spacing mark (Mc)”

UnicodeDigit ::
  any character in the Unicode category “Decimal number (Nd)”

UnicodeConnectorPunctuation ::
  any character in the Unicode category “Connector punctuation (Pc)”

UnicodeEscapeSequence :: See 7.6
  \u HexDigit HexDigit HexDigit 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

Punctuator :: one of
  {
  }
  { }
  .
  ;
  ,
  <
  >
  <=
  >=
  ==
  !=
  ===
  !==
  +
  -
  *
  %
  ++
  --
  <<
  >>
  >>>
  &
  |   ^
  !
  ~
  &&

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```

DivPunctuator :: one of

/ /=

Literal ::

NullLiteral
BooleanLiteral
NumericLiteral
StringLiteral

NullLiteral ::

null

BooleanLiteral ::

true
false

NumericLiteral ::

DecimalLiteral
HexIntegerLiteral

DecimalLiteral ::

DecimalIntegerLiteral . DecimalDigits ExponentPart opt
. DecimalDigits ExponentPart opt
DecimalIntegerLiteral ExponentPart opt

DecimalIntegerLiteral ::

0
NonZeroDigit DecimalDigits opt

DecimalDigits ::

DecimalDigit
DecimalDigits DecimalDigit

DecimalDigit :: one of

0 1 2 3 4 5 6 7 8 9

ExponentIndicator :: one of

e E

SignedInteger ::

DecimalDigits
+ DecimalDigits
- DecimalDigits
```

See 7.7

See 7.8

See 7.8.1

See 7.8.2

See 7.8.3

See 7.8.3

See 7.8.3

See 7.8.3

See 7.8.3

See 7.8.3

See 7.8.3

See 7.8.3

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HexIntegerLiteral ::
  0x HexDigit
  0X HexDigit
  HexIntegerLiteral HexDigit

StringLiteral ::
  " DoubleStringCharacters opt "
  ' SingleStringCharacters opt '

DoubleStringCharacters ::
  DoubleStringCharacter DoubleStringCharactersopt

SingleStringCharacters ::
  SingleStringCharacter SingleStringCharactersopt

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

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

LineContinuation ::
  \ LineTerminator

EscapeSequence ::
  CharacterEscapeSequence
  0 [lookahead DecimalDigit]
  HexEscapeSequence
  UnicodeEscapeSequence

CharacterEscapeSequence ::
  SingleEscapeCharacter
  NonEscapeCharacter

SingleEscapeCharacter ::
  " " b f n r t v

NonEscapeCharacter ::
  SourceCharacter but not EscapeCharacter or LineTerminator

EscapeCharacter ::
  SingleEscapeCharacter
  DecimalDigit x u

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HexEscapeSequence ::
  * HexDigit HexDigit

UnicodeEscapeSequence ::
  \ HexDigit HexDigit HexDigit HexDigit

RegularExpressionLiteral ::
  / RegularExpressionBody / RegularExpressionFlags

RegularExpressionBody ::
  RegularExpressionFirstChar RegularExpressionChars

RegularExpressionChars ::
  [empty]

RegularExpressionFirstChar ::
  NonTerminator but not * or \ or /
BackslashSequence

RegularExpressionChar ::
  NonTerminator but not \ or /
BackslashSequence

BackslashSequence ::
  \ NonTerminator

NonTerminator ::
  SourceCharacter but not LineTerminator

RegularExpressionFlags ::
  [empty]

A.2 Number Conversions

StringNumericLiteral :::
  StrWhiteSpace, StrWhiteSpace opt StrNumericLiteral StrWhiteSpace opt

StrWhiteSpace :::
  StrWhiteSpaceChar StrWhiteSpace opt

StrWhiteSpaceChar :::
  \ WhiteSpace
  LineTerminator

StrWhiteSpace, StrWhiteSpace opt...
A.3 Expressions

PrimaryExpression :
  this
  Identifier
  Literal
  ArraysLiteral
  ObjectLiteral
  ( Expression )
ArrayLiteral:
  [ Elision?, ElementList ], ElementList, Elision, ElementList

ElementList:
  Elision, AssignmentExpression
  ElementList, Elision, AssignmentExpression

Elision:

ObjectLiteral:
  { }
  { PropertyNameAndValueList } { PropertyNameAndValueList },

PropertyNameAndValueList:
  PropertyAssignment
  PropertyNameAndValueList, PropertyAssignment

PropertyAssignment:
  PropertyName: AssignmentExpression
  get PropertyName() { FunctionBody }
  set PropertyName(PropertySetParameterList) { FunctionBody },

PropertyName:
  Identifier
  StringLiteral
  NumericLiteral

PropertySetParameterList:
  Identifier

MemberExpression:
  PrimaryExpression
  FunctionExpression
  MemberExpression [ Expression ]
  MemberExpression . Identifier
  new MemberExpression Arguments

NewExpression:
  MemberExpression
  new NewExpression

CallExpression:
  MemberExpression Arguments
  CallExpression Arguments
  CallExpression [ Expression ]
  CallExpression . Identifier

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Arguments :

{} ( ) ArgumentList 

ArgumentList :

AssignmentExpression AssignmentList , AssignmentExpression 

LeftHandSideExpression :

NewExpression CallExpression 

PostfixExpression :


UnaryExpression :

PostfixExpression delete UnaryExpression void UnaryExpression ++ UnaryExpression -- UnaryExpression + UnaryExpression - UnaryExpression ~ UnaryExpression ! UnaryExpression 

MultiplicativeExpression :

UnaryExpression MultiplicativeExpression * UnaryExpression MultiplicativeExpression / UnaryExpression MultiplicativeExpression % UnaryExpression 

AdditiveExpression :

MultiplicativeExpression AdditiveExpression + MultiplicativeExpression AdditiveExpression - MultiplicativeExpression 

ShiftExpression :

AdditiveExpression ShiftExpression << AdditiveExpression ShiftExpression >> AdditiveExpression ShiftExpression >>> AdditiveExpression 

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RelationalExpression : See 11.8
  ShiftExpression
  RelationalExpression < ShiftExpression
  RelationalExpression > ShiftExpression
  RelationalExpression <= ShiftExpression
  RelationalExpression >= ShiftExpression
  RelationalExpression instanceof ShiftExpression
  RelationalExpression in ShiftExpression

RelationalExpressionNoIn : See 11.8
  ShiftExpressionNoIn
  RelationalExpressionNoIn < ShiftExpression
  RelationalExpressionNoIn > ShiftExpression
  RelationalExpressionNoIn <= ShiftExpression
  RelationalExpressionNoIn >= ShiftExpression
  RelationalExpressionNoIn instanceof ShiftExpression

EqualityExpression : See 11.9
  RelationalExpression
  EqualityExpression == RelationalExpression
  EqualityExpression != RelationalExpression
  EqualityExpression === RelationalExpression
  EqualityExpression !== RelationalExpression

EqualityExpressionNoIn : See 11.9
  RelationalExpressionNoIn
  EqualityExpressionNoIn == RelationalExpressionNoIn
  EqualityExpressionNoIn != RelationalExpressionNoIn
  EqualityExpressionNoIn === RelationalExpressionNoIn
  EqualityExpressionNoIn !== RelationalExpressionNoIn

BitwiseANDExpression : See 11.10
  EqualityExpression
  BitwiseANDExpression & EqualityExpression

BitwiseANDExpressionNoIn : See 11.10
  EqualityExpressionNoIn
  BitwiseANDExpressionNoIn & EqualityExpressionNoIn

BitwiseXORExpression : See 11.10
  BitwiseANDExpression
  BitwiseXORExpression ^ BitwiseANDExpression

BitwiseXORExpressionNoIn : See 11.10
  BitwiseANDExpressionNoIn
  BitwiseXORExpressionNoIn ^ BitwiseANDExpressionNoIn

BitwiseORExpression : See 11.10
  BitwiseXORExpression
  BitwiseORExpression | BitwiseXORExpression

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BitwiseORExpressionNoIn :
   BitwiseORExpressionNoIn
   BitwiseORExpressionNoIn | BitwiseXORExpressionNoIn

LogicalANDExpression :
   BitwiseORExpression
   LogicalANDExpression && BitwiseORExpression

LogicalANDExpressionNoIn :
   BitwiseORExpressionNoIn
   LogicalANDExpressionNoIn && BitwiseORExpressionNoIn

LogicalORExpression :
   LogicalANDExpression
   LogicalORExpression || LogicalANDExpression

LogicalORExpressionNoIn :
   LogicalANDExpressionNoIn
   LogicalORExpressionNoIn || LogicalANDExpressionNoIn

ConditionalExpression :
   LogicalORExpression
   LogicalORExpression ? AssignmentExpression : AssignmentExpression

ConditionalExpressionNoIn :
   LogicalORExpressionNoIn
   LogicalORExpressionNoIn ? AssignmentExpressionNoIn : AssignmentExpressionNoIn

AssignmentExpression :
   ConditionalExpression
   LeftHandSideExpression AssignmentOperator AssignmentExpression

AssignmentExpressionNoIn :
   ConditionalExpressionNoIn
   LeftHandSideExpression AssignmentOperator AssignmentExpressionNoIn

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

Expression :
   AssignmentExpression
   Expression , AssignmentExpression

ExpressionNoIn :
   AssignmentExpressionNoIn
   ExpressionNoIn , AssignmentExpressionNoIn

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A.4 Statements

Statement : SubStatement VariableStatement FunctionDeclaration


Block : { StatementListopt }

StatementList : Statement StatementList Statement

VariableStatement : var VariableDeclarationList ;

VariableDeclarationList : VariableDeclaration VariableDeclarationList , VariableDeclaration

VariableDeclarationListNoIn : VariableDeclarationNoIn VariableDeclarationListNoIn , VariableDeclarationNoIn

VariableDeclaration : Identifier Initialiseropt

VariableDeclarationNoIn : Identifier InitialiserNoInopt

Initialiser : = AssignmentExpression

InitialiserNoIn : = AssignmentExpressionNoIn

---

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EmptyStatement :
    ;

ExpressionStatement :
    [lookahead ∈ {1, function}] Expression ;

IfStatement :
    if ( Expression ) SubStatement else SubStatement
    if ( Expression ) SubStatement

IterationStatement :
    do SubStatement while ( Expression ) ;
    while ( Expression ) SubStatement
    for ( var VariableDeclarationListNoIn ; Expressionopt ; Expressionopt ) SubStatement
    for ( var VariableDeclarationListNoIn in Expression ) SubStatement
    for ( LeftHandSideExpression in Expression ) SubStatement

ContinueStatement :
    continue [no LineTerminator here] Identifieropt ;

BreakStatement :
    break [no LineTerminator here] Identifieropt ;

ReturnStatement :
    return [no LineTerminator here] Expressionopt ;

WithStatement :
    with ( Expression ) SubStatement

SwitchStatement :
    switch ( Expression ) CaseBlock

CaseBlock :
    { CaseClausesopt }
    { CaseClausesopt, DefaultClause CaseClausesopt }

CaseClause :
    CaseClause
    CaseClauses CaseClause

CaseClause :
    case Expression : StatementListopt

DefaultClause :
    default : StatementListopt

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LabelledStatement : Identifier ; Statement

ThrowStatement :
  throw Expression ;

TryStatement :
  try Block Catch CaseBlock

Catch :
  catch (Identifier ) Block

Finally :
  finally Block

DebuggerStatement :
  debugger ;

A.5 Functions and Programs

FunctionDeclaration :
  function Identifier ( FormalParameterList opt ) { FunctionBody }

FunctionExpression :
  function Identifier opt ( FormalParameterList opt ) { FunctionBody }

FormalParameterList :
  Identifier FormalParameterList , Identifier

FunctionBody :
  UseStrictDirective opt SourceElements

Program :
  UseStrictDirective opt SourceElements

UseStrictDirective opt :
  use strict " useExtension opt" ;

useExtension opt :
  , DoubleStringCharacters opt

SourceElements :
  SourceElement SourceElements

SourceElement :
  Statement FunctionDeclaration

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A.6 Universal Resource Identifier Character Classes

\[ uri ::= \]
\[ \text{uriCharacters}_{\text{opt}} \]

\[ \text{uriCharacters} ::= \]
\[ \text{uriCharacter uriCharacters}_{\text{opt}} \]

\[ \text{uriCharacter} ::= \]
\[ \text{uriReserved} \]
\[ \text{uriUnescaped} \]
\[ \text{uriEscaped} \]

\[ \text{uriReserved} ::= \text{one of} \]
\[ ; / ? : @ & = + $ , \]

\[ \text{uriUnescaped} ::= \]
\[ \text{uriAlpha} \]
\[ \text{DecimalDigit} \]
\[ \text{uriMark} \]

\[ \text{uriEscaped} ::= \]
\[ \% \text{HexDigit HexDigit} \]

\[ \text{uriAlpha} ::= \text{one of} \]
\[ a b c d e f g h i j k l m n o p q r s t u v w x y z \]
\[ A B C D E F G H I J K L M N O P Q R S T U V W X Y Z \]

\[ \text{uriMark} ::= \text{one of} \]
\[ - _ \ . ! * ( ) \]

A.7 Regular Expressions

\[ \text{Pattern} ::= \]
\[ \text{Disjunction} \]

\[ \text{Disjunction} ::= \]
\[ \text{Alternative} \]
\[ \text{Alternative} \setminus \text{Disjunction} \]

\[ \text{Alternative} ::= \]
\[ \text{[empty]} \]
\[ \text{Alternative Term} \]

\[ \text{Term} ::= \]
\[ \text{Assertion} \]
\[ \text{Atom} \]
\[ \text{Atom Quantifier} \]
Assertion ::

^ $ \ b \ B

Quantifier ::

QuantifierPrefix

QuantifierPrefix ?

QuantifierPrefix ::

* + ? { DecimalDigits } { DecimalDigits , } { DecimalDigits , DecimalDigits }

Atom ::

PatternCharacter

\ AtomEscape


PatternCharacter :: SourceCharacter but not any of: ^ $ \ . * + ? ( ) [ ] { } |

AtomEscape ::

DecimalEscape

CharacterEscape

CharacterClassEscape

CharacterEscape ::

ControlEscape c ControlLetter

HexEscapeSequence

UnicodeEscapeSequence

IdentityEscape

ControlEscape :: one of fnrtv

ControlLetter :: one of abcdefghijklmnopqrstuvwxyz ABCDEFGHIJKLMNOPQRSTUVWXYZ

07 November 2008
IdentityEscape ::
SourceCharacter but not IdentifierPart

DecimalEscape ::
DecimalIntegerLiteral [lookahead 'g DecimalDigit]

CharacterClass ::
[ [lookahead 'g \^] CharacterRanges ]
[ ^ CharacterRanges ]

CharacterRanges ::
[empty]
NonemptyCharacterRanges

NonemptyCharacterRanges ::
ClassAtom
ClassAtom NonemptyCharacterRangesNoDash
ClassAtom ^ ClassAtom CharacterRanges

NonemptyCharacterRangesNoDash ::
ClassAtom
ClassAtomNoDash NonemptyCharacterRangesNoDash
ClassAtomNoDash ^ ClassAtom CharacterRanges

ClassAtom ::
-
ClassAtomNoDash

ClassAtomNoDash ::
SourceCharacter but not one of \ - \ 
\ CharacterEscape

ClassEscape ::
DecimalEscape
b
CharacterEscape
CharacterClassEscape

07 November 2008
Annex B
(informative)

Compatibility

B.1 Additional Syntax

Past editions of ECMAScript have included additional syntax and semantics for specifying octal literals and octal escape sequences. These have been removed from this edition of ECMAScript. This non-normative annex presents uniform syntax and semantics for octal literals and octal escape sequences for compatibility with some older ECMAScript programs.

B.1.1 Numeric Literals

The syntax and semantics of 7.8.3 can be extended as follows:

Syntax

```
NumericLiteral ::=  
  DecimalLiteral  
  HexIntegerLiteral  
  OctalIntegerLiteral

OctalIntegerLiteral ::=  
  0 OctalDigit  
  OctalIntegerLiteral OctalDigit
```

Semantics

```
The MV of NumericLiteral :: OctalIntegerLiteral is the MV of OctalIntegerLiteral.
The MV of OctalDigit :: 0 is 0.
The MV of OctalDigit :: 1 is 1.
The MV of OctalDigit :: 2 is 2.
The MV of OctalDigit :: 3 is 3.
The MV of OctalDigit :: 4 is 4.
The MV of OctalDigit :: 5 is 5.
The MV of OctalDigit :: 6 is 6.
The MV of OctalDigit :: 7 is 7.
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.
```

B.1.2 String Literals

The syntax and semantics of 7.8.4 can be extended as follows:

Syntax

```
EscapeSequence ::=  
  CharacterEscapeSequence  
  OctalEscapeSequence  
  HexEscapeSequence  
  UnicodeEscapeSequence
```

07 November 2008
OctalEscapeSequence :: 
  OctalDigit [lookahead @ DecimalDigit]
  ZeroToThree OctalDigit [lookahead @ DecimalDigit]
  FourToSeven OctalDigit
  ZeroToThree OctalDigit OctalDigit

ZeroToThree :: one of
  0 1 2 3

FourToSeven :: one of
  4 5 6 7

Semantics

The CV of EscapeSequence :: OctalEscapeSequence is the CV of the OctalEscapeSequence.
The CV of OctalEscapeSequence :: OctalDigit [lookahead @ DecimalDigit] is the character whose code point value is the MV of the OctalDigit.
The CV of OctalEscapeSequence :: ZeroToThree OctalDigit [lookahead @ DecimalDigit] is the character whose code point value is (8 times the MV of the ZeroToThree) plus the MV of the OctalDigit.
The CV of OctalEscapeSequence :: FourToSeven OctalDigit is the character whose code point value is (8 times the MV of the FourToSeven) plus the MV of the OctalDigit.
The CV of OctalEscapeSequence :: ZeroToThree OctalDigit OctalDigit is the character whose code point value is (64 (that is, $8^2$) 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 MV of FourToSeven :: 4 is 4.
The MV of FourToSeven :: 5 is 5.
The MV of FourToSeven :: 6 is 6.
The MV of FourToSeven :: 7 is 7.

B.2 Additional Properties

Some implementations of ECMAScript have included additional properties for some of the standard native objects. This non-normative annex suggests uniform semantics for such properties without making the properties or their semantics part of this standard.

B.2.1 escape (string)

The escape function is a property of the global object. It computes a new version of a string value in which certain characters have been replaced by a hexadecimal escape sequence.

For those characters being replaced whose code point value is $0xFF$ or less, a two-digit escape sequence of the form $%xx$ is used. For those characters being replaced whose code point value 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 (represented as a 16-bit unsigned integer) at position k within Result(1).
7. If Result(6) is one of the 69 nonblank characters
   "ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789@*_+-./"
   then go to step 13.

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8. If \( \text{Result}(6) \) is less than 256, go to step 11.
9. Let \( S \) be a string containing six characters \( \%uwxyz \) where \( wxyz \) are four hexadecimal digits encoding the value of \( \text{Result}(6) \).
11. Let \( S \) be a string containing three characters \( \%xy \) where \( xy \) are two hexadecimal digits encoding the value of \( \text{Result}(6) \).
13. Let \( S \) be a string containing the single character \( \text{Result}(6) \).
15. Let \( R \) be a new string value computed by concatenating the previous value of \( R \) and \( S \).
16. Go to step 5.

**NOTE**
The encoding is partly based on the encoding described in RFC1738, but the entire encoding specified in this standard is described above without regard to the contents of RFC1738.

### B.2.2 unescape (string)

The `unescape` function is a property of the global object. It computes a new version of a string value in which each escape sequence 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 \( \text{Result}(1) \).
3. Let \( R \) be the empty string.
4. Let \( k \) be 0.
5. If \( k \) equals \( \text{Result}(2) \), return \( R \).
6. Let \( c \) be the character at position \( k \) within \( \text{Result}(1) \).
7. If \( c \) is not \( \% \), go to step 18.
8. If \( k \) is greater than \( \text{Result}(2) \)–6, go to step 14.
9. If the character at position \( k+1 \) within \( \text{Result}(1) \) is not \( u \), go to step 14.
10. If the four characters at positions \( k+2, k+3, k+4, \) and \( k+5 \) within \( \text{Result}(1) \) are not all hexadecimal digits, go to step 14.
11. Let \( c \) be the character whose code point value is the integer represented by the four hexadecimal digits at positions \( k+2, k+3, k+4, \) and \( k+5 \) within \( \text{Result}(1) \).
12. Increase \( k \) by 5.
14. If \( k \) is greater than \( \text{Result}(2) \)–3, go to step 18.
15. If the two characters at positions \( k+1 \) and \( k+2 \) within \( \text{Result}(1) \) are not both hexadecimal digits, go to step 18.
16. Let \( c \) be the character whose code point value is the integer represented by two zeroes plus the two hexadecimal digits at positions \( k+1 \) and \( k+2 \) within \( \text{Result}(1) \).
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.

### B.2.3 String.prototype.substr (start, length)

The `substr` method takes two arguments, `start` and `length`, and returns a substring of the result of converting this object to a string, starting from character position `start` and running for `length` characters (or through the end of the string if `length` is `undefined`). If `start` is negative, it is treated as `(sourceLength+start)` where `sourceLength` is the length of the string. The result is a string value, not a `String` object. The following steps are taken:

1. Call `ToString`, giving it the `this` value as its argument.
2. Call `ToInteger(start)`.
3. If `length` is `undefined`, use `+∞`; otherwise call `ToInteger(length)`.
4. Compute the number of characters in `\text{Result}(1)`.

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5. If Result(2) is positive or zero, use Result(2); else use max(Result(4)+Result(2),0).
6. Compute min(max(Result(3),0), Result(4)-Result(5)).
7. If Result(6) ≤ 0, return the empty string “”.
8. Return a string containing Result(6) consecutive characters from Result(1) beginning with the character at position Result(5).

The length property of the substr method is 2.

NOTE
The substr 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.

B.2.4 Date.prototype.getYear ( )

NOTE
The getFullYear method is preferred for nearly all purposes, because it avoids the “year 2000 problem.”

When the getYear method is called with no arguments the following steps are taken:
1. Let t be this time value.
2. If t is NaN, return NaN.
3. Return YearFromTime(LocalTime(t)) - 1900.

B.2.5 Date.prototype.setYear (year)

NOTE
The setFullYear method is preferred for nearly all purposes, because it avoids the “year 2000 problem.”

When the setYear method is called with one argument year the following steps are taken:
1. Let t be the result of LocalTime(this time value); but if this time value is NaN, let t be +0.
2. Call ToNumber(year).
3. If Result(2) is NaN, set the [[PrimitiveValue]] property of the this value to NaN and return NaN.
4. If Result(2) is not NaN and 0 ≤ ToInteger(Result(2)) ≤ 99 then Result(4) is ToInteger(Result(2)) + 1900. Otherwise, Result(4) is Result(2).
5. Compute MakeDay(Result(4), MonthFromTime(t), DateFromTime(t)).
6. Compute UTC(MakeDate(Result(5), TimeWithinDay(t))).
7. Set the [[PrimitiveValue]] property of the this value to TimeClip(Result(6)).
8. Return the value of the [[PrimitiveValue]] property of the this value.

B.2.6 Date.prototype.toGMTString ( )

NOTE
The property toUTCString is preferred. The toGMTString property is provided principally for compatibility with old code. It is recommended that the toUTCString property be used in new ECMAScript code.

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.
Annex C

This annex needs to be updated according to the rest of the document.

The Strict variant of ECMAScript

C.1 Excluded Features

1. When defined within an execution context subset restricted to the strict subset, a function may not have two or more formal parameters that have the same name. An attempt to create such a function will fail, either statically, if expressed as a FunctionDeclaration or FunctionExpression, or dynamically by throwing a SyntaxError exception, if expressed in a call to the Function constructor (10.1.3.1).

2. For functions defined within an execution context subset restricted to the strict subset, if an arguments object is created, a callee property is not created. The arguments object does not share properties with the activation object. Changing the value of a arguments object property does not change the value of the corresponding argument value and vice versa (10.1.8.1).

3. If either the execution context for the eval code or the execution context in which the eval operator was executed is subset restricted to the strict subset, the eval code cannot instantiate variables, functions, or constants in the lexical context of its eval operator. Instead, a new environment object is appended to the head of the calling context’s scope chain and that environment object is used for environment bindings instantiation with the eval code (10.2.2.1).

4. If this is evaluated within an execution context that is subset restricted to the strict subset, then the this value is not coerced.

5. When a postfix increment operator occurs within an execution context that is subset restricted to the strict subset, its LeftHandSide must not be a reference to a property with the attribute value (false) nor to a non-existent property of an object whose [Extensible] property has the value false. In these cases a TypeError exception is thrown (11.3.1.1).

6. The same restrictions as specified in 11.3.1.1 apply for the postfix decrement operator (11.3.2.1).

7. When a delete operator occurs within an execution context that is subset restricted to the strict subset, its UnaryExpression is further limited to being a MemberExpression. In addition, if the property to be deleted has the attribute { [[Configurable]]: false }, a TypeError exception is thrown (11.4.1.1).

8. The same restrictions as specified in 11.3.1.1 apply for the prefix increment operator (11.4.4.1).

9. The same restrictions as specified in 11.3.1.1 apply for the prefix decrement operator (11.4.5.1).

10. When a simple assignment occurs within an execution context that is subset restricted to the strict subset, its LeftHandSide must not evaluate to a Reference whose base is null. If it does a ReferenceError exception is thrown. The LeftHandSide also may not be a reference to a property with the attribute value (false) nor to a non-existent property of an object whose [Extensible] property has the value false. In these cases a TypeError exception is thrown (11.13.1.1).

11. A VariableStatement within an execution context that is subset restricted to the strict subset, may not occur as the StatementList of a Block. The occurrence of a VariableStatement in such a context must be treated as a syntax error (12.1.1).

12. An execution context that is subset restricted to the strict subset, may not execute a WithStatement. The occurrence of a WithStatement in such a context should be treated as a syntax error (12.10.1).

13. If an execution context that is subset restricted to the strict subset uses the value of the eval property in any way other than a direct call (that is, other than by the explicit use of its name as an Identifier which is the MemberExpression in a CallExpression), or if the eval property is assigned to, an EvalError exception is thrown (15.1.2.1.1).

14. If an execution context that is subset restricted to the strict subset uses the Function.caller, Function.arguments, or arguments.caller properties in any way, a TypeError exception should be thrown.

C.1.2 Additional Execution Exceptions
Annex D
(informative)

Note:
This annex needs to be updated according to the rest of the document.

Correction and Clarifications in Edition 3.1 with Possible Compatibility Impact

Throughout: The meaning of phrases such as “as if by the expression `new Array()`” are subject to misinterpretation. The specification text for all internal references and invocations of standard built-in objects and methods has been clarified by making it implicit that the intent is that the actual built-in object is to be used rather than the current dynamic value of the correspondingly name property.

11.8.2, 11.8.3,11.8.5 While ECMAScript generally uses a left to right evaluation order the specification language for the `>` and `<` operators resulted a partial right to left order. The specification has been corrected for these operators such that it now specifies a full left to right evaluation order. However, this change of order is potentially observable if user-defined valueOf or toString methods with side-effects are invoked during the evaluation process.

11. 2.3 Edition 3.1 reverses the order of steps 2 and 3 of the algorithm. The original order as specified in Editions 1 through 3 was incorrectly specified such that side-effects of evaluating Arguments could effect the result of evaluating MemberExpression.

15.10.6 RegExp.prototype is now a RegExp object rather than an instance of Object. The value of its `[[Class]]` internal property which is observable using Object.prototype.toString is now “RegExp” rather than “Object”
Annex E
(informative)

Note:
This annex needs to be updated according to the rest of the document.

Section 7.1 Unicode format control characters are no longer stripped from ECMAScript source text before processing. Unicode BOMs (byte order marks) are treated as whitespace.
Section 7.8.5 Regular expression literals now return an unique object each time the literal is evaluated. This change is detectable by any programs that test the object identity of such literal values or that are sensitive to the shared side effects.
Section 12.6.4 for-in statements no longer throw a TypeError if the in expression evaluates to null or undefined. Instead, the statement behaves as if the value of the expression was an object with no enumerable properties.
Section 15: Implementations are now required to ignore extra arguments to standard built-in methods unless otherwise explicitly specified. In the 3rd Edition the handling of extra arguments were undefined and implementations were explicitly allowed to throw a TypeError exception.
Section 15.1.1: The value properties NaN, Infinity, and undefined of the Global Object have been changed to be read-only properties.
Section 15.9.4.2: Date.parse is not required to first attempt to parse its argument as an ISO format string. Programs that use this format but depended upon implementation specific behavior (including failure) may behave differently.

Comment [AWB63]: What is the justification for this change?
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<table>
<thead>
<tr>
<th>Date</th>
<th>Author</th>
<th>Revision Details</th>
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<tbody>
<tr>
<td>07 November 2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 May 2008</td>
<td>pratapL</td>
<td>Updated to introduce the following: Strict mode, infrastructure for the introduction of getters/setters, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>improvements to String, Date, Array, Function, and Object. Removed the notions of equating and joining.</td>
</tr>
<tr>
<td>9 June 2008</td>
<td>pratapL</td>
<td>Added Array generics (§15.4.4.14 to 15.4.4.22)</td>
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<tr>
<td></td>
<td></td>
<td>Added support for “abc”[0] (§8.6.2.1.2).</td>
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<td></td>
<td></td>
<td>Reverted the change to separate internal properties on functions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Changed Unicode Version to 4.0.</td>
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<tr>
<td>11 June 2008</td>
<td>pratapL</td>
<td>Updated 15.9.1.15 (Date Time string format) calling out that it is not required for all the fields in the ISO date format to be present.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integrated first draft of JSON changes</td>
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<tr>
<td></td>
<td></td>
<td>Applied styles uniformly for NOTEs.</td>
</tr>
<tr>
<td>14 June 2008</td>
<td>pratapL</td>
<td>Incorporated basic placeholders for Decimal.</td>
</tr>
<tr>
<td>15 June 2008</td>
<td>pratapL</td>
<td>Incorporated updated JSON exposition.</td>
</tr>
<tr>
<td>24 June 2008</td>
<td>pratapL</td>
<td>All changes related to introduction of internal [[Extensible]] property and updating the statics on Object:</td>
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<tr>
<td></td>
<td></td>
<td>4.3.3 – abbreviated the definition of object.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3.24 – added 214 clarifying note: function contains executable code</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3.25 to 4.3.28 – added definitions for property, method, attribute, own property, inherited property</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.6.1 – changed title text to add ‘and Descriptors’. Changed first and second para to introduce clarifying text – introduced Ddesc and Pdesc formally.</td>
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<tr>
<td></td>
<td></td>
<td>8.6.2 – introduced [[Extensible]], removed [[Dynamic]], restored allowances for host objects, and added clarifying section text.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.6.2.1.3 – updated to use [[Extensible]]</td>
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<td></td>
<td>8.6.2.2 – updated to use [[Extensible]]; steps that said ‘throw something’ now say ‘throw TypeError’.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.6.2.5 – step that said ‘throw something’ now says ‘throw TypeError’.</td>
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<tr>
<td></td>
<td></td>
<td>10.1.8 – property attributes for each non-negative integer arg specified.</td>
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<tr>
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<td>13.2.1, 13.2.2 – updated steps to use [[Extensible]]</td>
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<td>15.2.3.15 – object statics specified.</td>
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<td>15.2.4 onwards – called out the initial value of the internal [[Extensible]] property.</td>
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<tr>
<td>28 June 2008</td>
<td>pratapL</td>
<td>7.8.4, Annex A – introduced ‘LineContinuation’ to account for string literals with line terminators.</td>
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<tr>
<td>29 June 2008</td>
<td>pratapL</td>
<td>4.2 onwards – changed Writeable to Writable</td>
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<td>4.2.2 – removed “Strict and Non-Strict Modes” and replaced with “Language Subset Selection” (placeholder)</td>
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<tr>
<td></td>
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<td>4.3.7 – introduced built-in constructor</td>
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<td></td>
<td></td>
<td>4.3.24 – fixed nature of a function</td>
</tr>
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<td></td>
<td>4.3.29 – added Built-in Method</td>
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<td></td>
<td>7.8.5 – minor language cleanup</td>
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<td>8.5 – fixed reference to sections 9.5 and 9.6</td>
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<td>8.6.1 onwards – Property Attributes; changed [[Dynamic]] to [[Flexible]], introduced default values for the attributes, changed ‘Strict’ flag to ‘Throw’ flag, changed [[SetOwnProperty]] to [[DefineOwnProperty]], added [[ThrowablePut]]</td>
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<tr>
<td></td>
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<td>8.6.2.2 – removed ‘Strict’ flag from [[Put]]</td>
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<td>8.6.2.2.1 – introduced [[ThrowablePut]]</td>
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<td></td>
<td></td>
<td>8.6.2.7 to 8.6.2.10 – added new internal properties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.10 – introduced whole new section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.10 – introduced IsCallable</td>
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<td></td>
<td></td>
<td>12.2 – introduced const into the grammar</td>
</tr>
<tr>
<td>Date</td>
<td>Author</td>
<td>Changes</td>
</tr>
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<td>30 June 2008</td>
<td>pratpl</td>
<td>11.1.5 – introduced syntactic sections for getters/setters in object literals</td>
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<td>1 July 2008</td>
<td>pratpl</td>
<td>Integrated Unicode changes.</td>
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<td>2 July 2008</td>
<td>pratpl</td>
<td>[Integrated changes from Allen]</td>
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<td>4 July 2008</td>
<td>pratpl</td>
<td>7.2 – added &lt;NEL&gt; as a white space character.</td>
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<td>7.3.2 – reverted the change that made eval a keyword</td>
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<td>7.8.4 – allowed embedded LineTerminator in string literals provided they are not followed by white space.</td>
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<tr>
<td></td>
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<td>8 – introduced Property Descriptor and Property Identifier as new types.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.6.1 – introduced [[Const]] as a property attribute.</td>
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<td></td>
<td></td>
<td>8.6.2.1, 8.6.2.3, 8.6.2.9, 8.6.2.10 – updated the algorithms to account for [[Const]].</td>
</tr>
<tr>
<td></td>
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<td>10.1.2, 10.1.3, 12.12.1, 12.2, 12.5, 12.6, 12.6.1, 12.6.2, 12.6.3, 12.6.4, 12.10, 12.15 – introduced Const statements, lexical scoping of consts and function declarations, restricting declarations from use as &quot;pseudo blocks&quot;.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.13.2 – deleted this section and added 12.1.1 instead.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.13.5.19 – made roundingMode an optional argument.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.3.2.16 – added 'Draft' watermark to main content section (section 4), and 'saved date' in the footer of the page.</td>
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<tr>
<td></td>
<td></td>
<td>Regenerated TOC.</td>
</tr>
<tr>
<td>14 July 2008</td>
<td>pratpl</td>
<td>4 – updated the Scheme reference to R6RS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.1.4 - fixed reference to Syntactic grammar.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.8.4 - clarified \NonEscapeCharacter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.8.4 - introduced u ( { }) syntax for Unicode escape sequences.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.1.2.3 – fixed reference to \StrDecimalLiteral.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.2.3.2 through 15.2.3.14 – changed first step to throw a TypeError exception if the first parameter was not of type Object.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.2.3.15 – introduced Object.keys static method.</td>
</tr>
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<td></td>
<td></td>
<td>15.3.2.1 – adding the &quot;name&quot; and &quot;parameters&quot; properties in the Function Constructor algorithm (steps 17, 18).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.3.5.4 – introduced the &quot;name&quot; property.</td>
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<td></td>
<td>15.3.5.5 – introduced the &quot;parameters&quot; property.</td>
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<td></td>
<td>15.5.4.21 - introduced String.prototype.toJSON.</td>
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<tr>
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<td></td>
<td>15.6.4.4 - introduced Boolean.prototype.toJSON.</td>
</tr>
<tr>
<td>Date</td>
<td>Author</td>
<td>Changes</td>
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<tr>
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<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>15 July 2008</td>
<td>pratapL</td>
<td>8.6.2 - changed \rightarrow \rightarrow to \rightarrow in internal properties table.</td>
</tr>
<tr>
<td></td>
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<td>8.6.2.3 - added check for &quot;readonly&quot; accessor properties to ([\text{CanPut}]).</td>
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<td>10.1.2 - removed the ability to include UseSubsetDirective in the code of a function body passed as a string to the Function constructor.</td>
</tr>
<tr>
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<td></td>
<td>10.2.4 - new section.</td>
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<tr>
<td></td>
<td></td>
<td>12.1 - various tweaks to match changes to section 10.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.6.4 - made for-in ignore expressions whose values are either null or undefined rather than throwing a TypeError.</td>
</tr>
<tr>
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<td></td>
<td>12.14 - update catch semantics to match changes to sections 10 and 12.1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.2.3.2 - moved getOwnProperty to 15.2.3.3.</td>
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<tr>
<td></td>
<td></td>
<td>15.2.3.3 - moved getProperty to 15.2.3.4.</td>
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<tr>
<td></td>
<td></td>
<td>15.2.3.4 - eliminated getOwnProperty method.</td>
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<tr>
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<td></td>
<td>15.2.3.5 - added not stating that implicit string properties,</td>
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<td>corresponding to character positions are not included in the returned</td>
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<td></td>
<td>property descriptor.</td>
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<td></td>
<td></td>
<td>15.2.3.5 - corrected algorithm to correctly deal with shadowed inherited</td>
</tr>
<tr>
<td></td>
<td></td>
<td>properties.</td>
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<td></td>
<td>15.2.3.5 - eliminated method getProperties, replaced with</td>
</tr>
<tr>
<td></td>
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<td>getOwnPropertyNames.</td>
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<td></td>
<td></td>
<td>15.2.3.8 - changed name of second argument.</td>
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<td></td>
<td>15.2.3.9 - reinstated optional second argument to Object.create.</td>
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<td>15.2.3.14 - moved getPrototypeOf to 15.2.3.2.</td>
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<td></td>
<td></td>
<td>15.2.3.2 through 15.2.3.13 - defined a length property for the function.</td>
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<td>A.5 - sync Program grammar in appendix with that in 14.</td>
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<tr>
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<td></td>
<td>Throughout most in section 10: changed the term &quot;variable object&quot; to</td>
</tr>
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<td></td>
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<td>&quot;environment object&quot; and the term &quot;variable instantiation&quot; to &quot;environment binding instantiations&quot;.</td>
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<td></td>
<td>Major overhaul of section 10 to better accommodate block scoped consns and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>function declarations.</td>
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<tr>
<td>4 Aug 2008</td>
<td>pratapL</td>
<td>Incorporated the following based on the Oslo review:</td>
</tr>
<tr>
<td></td>
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<td>4 - updated the Scheme reference to the IEEE standard.</td>
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<td></td>
<td>7.8.4, A.1 - reverted the addition of <code>u { UnicodeHexEscapeSequence }</code>, the</td>
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<td>UnicodeHexEscapeSequence production, and the elaboration on its CV.</td>
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<td>7.2-7.3, A.1 - restored <code>&lt;LS&gt;</code> and <code>&lt;PS&gt;</code> as line termination characters.</td>
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<td>Made <code>&lt;CR&gt;</code> <code>&lt;LF&gt;</code> a line terminator.</td>
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<td></td>
<td>7.8.4, A.1 - restored original definition of NonEscapeCharacter.</td>
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<td>7.8 5 - call out scan time reporting of invalid RegExp literals.</td>
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<td>8.6.2 - changed term &quot;procedural property&quot; to &quot;accessor property&quot;, removed</td>
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<td></td>
<td>stray mention of <code>[[Identity]]</code>.</td>
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<td>8.6.2.1 - changed references to Result(4) to Result(5).</td>
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<td>8.6.2.10 - removed redundant call to <code>[[GetOwnProperty]](O, P)</code> in step 5.</td>
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<td>10.1.2.3 - updated this class number to be 10.1.2.1.</td>
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<td></td>
<td>15.4.21, 15.6.4.4, 15.7.4.8 - added &quot;key&quot; as a parameter to the toJSON</td>
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<tr>
<td></td>
<td></td>
<td>functions.</td>
</tr>
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<td></td>
<td>15.12.2 - updated step 5.b.i to call V.toJSON(KEY); updated step 5.c.i to</td>
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<tr>
<td></td>
<td></td>
<td>call replacer.call(object, KEY, V).</td>
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<td></td>
<td>8.6.2.4 - corrected and refactored algorithm.</td>
</tr>
<tr>
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<td>8.6.2.9 - made any attribute change to a &quot;flexible&quot; data property acceptable.</td>
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<tr>
<td></td>
<td></td>
<td>8.10.1 - inlined IsValidDescriptor into ToPropertyDescriptor. Removed</td>
</tr>
<tr>
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<td></td>
<td>other references and deleted definition causing renumber of other definitions.</td>
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<tr>
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<td>8.10.5 - (FromPropertyDescriptor) changed undefined arg result and deleted</td>
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<td>bogus step 8.</td>
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<tr>
<td></td>
<td></td>
<td>8.10.6 - (ToPropertyDescriptor) corrections in steps 1 and 9b.</td>
</tr>
<tr>
<td>Date</td>
<td>Author</td>
<td>Changes</td>
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<td>-------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 11 Aug 2008| pratapL | 11.3.1, 11.3.2, 11.4.4, 11.4.5, 11.4.6, 11.4.7, 11.5, 11.8.1, 11.8.2, 11.8.3, 11.8.4 - incorporated changes to introduce support for Decimal.  
15.2.3.2 - deleted Object.getOwnProperty; renumbered the remaining sections under 15.2.3.  
15.2.3.3 - renamed Object.getOwnPropertyDescriptor to Object.getPropertyDescriptor.  
15.2.3.11 - renamed Object.nonExtensible to Object.preventExtensions. |
| 18 Aug 2008| pratapL | 11.3.1, 11.3.2, 11.4.4, 11.4.5, 11.4.6, 11.4.7, 11.5, 11.6.1, 11.6.2, 11.8.1, 11.8.2, 11.8.3, 11.8.4, 11.8.5, 11.9.3 - incorporated changes to these operators' support for Decimal to use the (yet to be defined) Form() and ToDouble() "specification helper functions". |
| 01 Sep 2008| pratapL | 11.1.5 - Fixed a typo in the step 4 of the algorithms for get/set property name.  
11.3.1, 11.3.2, 11.4.4, 11.4.5, 11.4.6, 11.4.7, 11.5, 11.6.1, 11.6.2, 11.8.1, 11.8.2, 11.8.3, 11.8.4, 11.8.5, 11.9.3, and 11.9.6 - incorporated Decimal related changes; these revert the introduction of the Form() and ToDouble() specification helper functions, and introduces calls to instanceof and Decimal functions. Handling of NaNs in comparisons has been changed to make the result more consistent with ES3.  
Renamed the [[Flexible]] attribute to [[Configurable]] and updated all references to it. |
| 22 Sep 2008| pratapL | Decimal is now a primitive, with a wrapper.  
4.3.30, 4.3.31, 4.3.32 - added new sections for Decimal.  
4.3.2, 9.9, 9.10, 11.3.1, 11.3.2, 11.4.3, 11.4.4, 11.4.5, 11.4.6, 11.4.7, 11.5, 11.6.1, 11.6.2, 11.8.1, 11.8.2, 11.8.3, 11.8.4, 11.9.3, 11.9.6, 15.1.2.4, 15.1.2.5, 15.13.2 - updated all relevant operators.  
15.13.4.1 - deleted Decimal.valueOf()  
15.13.4.2, through 15.13.4.9 - introduced new statics on Decimal  
15.13.5.14, 15.13.5.15 – introduced Infinity and NaN on Decimal  
15.13.5.16 through 15.13.5.43 - deleted these functions.  
7.9.1.1 - introduced restriction in cautious subset for automatic semicolon insertion that results in dead code to detect a SyntaxError.  
8.10.5 - minor correction of spelling mistake (DescObj changed to Desc).  
15.3.4:5 - incorporated algorithmic steps for Function.prototype.bind  
15.9.4.4 - introduced Date.now()  
15.12.1 - introduced restriction in JSON.parse that key strings within an object must be unique. |
<p>|            |         | C.1.1 - updated restriction (1) according to 7.9.1.1; added restrictions (15) and (16). |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Author</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 Oct 2008</td>
<td>pratapL</td>
<td>4.3.3, 4.3.24, 4.3.25, 4.3.28, 4.3.30 - added clarifications in the definitions of Function, Property, Own Property, and Built-in Method.</td>
</tr>
<tr>
<td>13 Oct 2008</td>
<td>pratapL</td>
<td>5.2 - added illustrative numbering for the algorithm steps.</td>
</tr>
<tr>
<td></td>
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<td>7.1 - corrected minor spelling.</td>
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<td></td>
<td>8.6.1 - Table 1: removed [[Const]]. Simplified description for [[Writable]].</td>
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<td>4.6.2 - restored original text that said that the description of the internal properties was for “native” ECMAscript objects. Updated second column header to be “Value Domain”, and updated second column for every internal property.</td>
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<td></td>
<td>8.6.2.1 - corrected step numbering in steps 5, 7.</td>
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<tr>
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<td></td>
<td>8.6.3.3 - updated the algorithm in steps 2, 7, and added a clarifying note.</td>
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<tr>
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<td>8.6.2 - updated the algorithm introducing steps 2 through 8.</td>
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<td></td>
<td>8.7 - restored original text on the non-provision within the spec for functions (built-in, and user defined) returning a reference.</td>
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<td></td>
<td></td>
<td>8.10 - clarifications regarding absent fields, and object literal syntax for Property Descriptors.</td>
</tr>
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<td></td>
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<td>8.10.1, 8.10.2, 8.10.3 - updated the algorithms to account for absent fields.</td>
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<td>8.10.4 - updated algorithm removing the checks for “Unspecified”.</td>
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<tr>
<td></td>
<td></td>
<td>8.10.5 - updated algorithm removing the checks for “Unspecified”; and corrected step numbering in steps 13d, 15, 15d.</td>
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<tr>
<td></td>
<td></td>
<td>9.10 - clarified the result of IsCallable on Object.</td>
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<td>10.1.2 - clarified exclusions for “lexical block code”.</td>
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<td></td>
<td>10.1.2.1 - added to the classification of “unrestricted” code.</td>
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<td></td>
<td>10.2 - clarified that a thrown exception may exit one or more execution contexts.</td>
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<td></td>
<td>11.1.1.1 - Removed this section.</td>
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<td></td>
<td>11.3.1.1 - corrected step numbers that need to be replaced, and provided the new steps.</td>
</tr>
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<td></td>
<td>11.9.3 - corrected step numbering in step 1, and changed to an ‘or’ condition in step 4.</td>
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<td></td>
<td></td>
<td>11.13.1.1 - clarified restriction on assigning to implicit global variables, and corrected the step number that needs to be replaced.</td>
</tr>
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<td>12.1 - corrected minor spelling.</td>
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<td></td>
<td></td>
<td>12.2 - clarified interaction between Block and VariableDeclaration, fixed step 4 in the production VariableDeclaration: Identifier Initialiser.</td>
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<td></td>
<td>12.6.4 - corrected steps 6, 8 in the first algorithm, and step 9 in the second algorithm.</td>
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<td>12.6.4.1 - corrected the replacement steps mentioning the right Results.</td>
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<td></td>
<td>12.10.1 - made the syntax error to be mandatory.</td>
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<td></td>
<td>12.15 - clarified semantics around access to const.</td>
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<td>13.2 - replaced mention of “properties” with “parameters”.</td>
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<td>14.2 - updated “use subset …” to “use strict …”</td>
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<td></td>
<td>15.2.3.15 - corrected step numbering for the algorithm.</td>
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<td></td>
<td>15.3.5.2 - updated [[Enumerable]] to be false.</td>
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<td></td>
<td>15.3.5.5 - removed this section (it was about “parameters”).</td>
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<tr>
<td></td>
<td></td>
<td>15.4.3.2 - clarified definition of isArray.</td>
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<td></td>
<td>15.10.7.5 - updated [[Writable]] to be true.</td>
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<td></td>
<td>15.12.1 - corrected step 2 to mention T instead of I.</td>
</tr>
<tr>
<td>20 Oct 2008</td>
<td>pratapL</td>
<td>The “cautious” subset is now strict mode.</td>
</tr>
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<td>4, 4.2.2, 10.1.3.1, 10.1.6.1, 10.1.8.1, 10.2.2.1, 11.3.1.1, 11.4.1.1, 11.13.1.1, 12.11.1, 12.10.1, 15.1.2.1.1, C.1.1 - renamed “cautious” to “strict”</td>
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<td></td>
<td>7.9.1.1 - removed this section (this was related to semicolon insertion in strict mode).</td>
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<td>10.1.6.1, 10.1.8.1, 10.2.2.1, 11.3.1.1, 11.3.2.1, 11.4.1.1, 11.4.4.1, 11.4.5.1, C.2.3.1 - added redefining of “strict” mode here.</td>
</tr>
<tr>
<td>Date</td>
<td>Author</td>
<td>Changes</td>
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<tr>
<td>219</td>
<td></td>
<td>11.13.1.1, 11.13.2.1, 12.1.1, 12.6.4.1, 12.10.1, 15.1.2.1.1 - removed</td>
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<td>&quot;cautious&quot; from the section heading,</td>
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<td>C.1 - replaced &quot;cautious&quot; with &quot;strict&quot; in the section heading.</td>
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<td>C.1.1 - deleted the first exclusion (this was related to semicolon</td>
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<td>insertion in strict mode.</td>
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<td>14 - Updated the productions for <code>UseSubsetDirective</code></td>
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<tr>
<td>07 Nov 2008</td>
<td>pratapl.</td>
<td>15.2.3.6 - removed this section (this was about Object.clone), and</td>
</tr>
<tr>
<td></td>
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<td>renumbered subsequent sections.</td>
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<tr>
<td>07 Nov 2008</td>
<td>pratapl.</td>
<td>15.5.4.21, 15.6.4.4, 15.7.4.8, 15.9.5.44 - specified the toJSON methods</td>
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<tr>
<td></td>
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<td>using pseudo-code.</td>
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<td></td>
<td>15.12.1 - Updated the note with behaviour in the case of duplicate key</td>
</tr>
<tr>
<td></td>
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<td>strings; duplicate key strings are now permitted.</td>
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<td>15.2.3.2 through 15.2.3.14, 15.3.4.5, 15.4.4.14 through 15.4.4.22 -</td>
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<td></td>
<td></td>
<td>removed redundant specification of the value of the length property for</td>
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<td>these methods on the native objects. It is already specified in section</td>
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<td></td>
<td></td>
<td>15.4.4.22 - change reduceright to reduceRight</td>
</tr>
<tr>
<td>27 Oct 2008</td>
<td>pratapl.</td>
<td>8.6.2.9 - removed an unnecessary reference in step 6, fixed minor</td>
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<td></td>
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<td>typos in steps 9.b.1 and 9.c.1.</td>
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<td>11.2.3 - swapped the order for steps 2, 3, and updated references to</td>
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<td>these step numbers in the rest of the algorithm; with this, the value</td>
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<td>of the <code>MemberExpression</code> will determine what function gets called even</td>
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<td>before the <code>Arguments</code> have been evaluated (and potentially caused side</td>
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<td>effects).</td>
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<td></td>
<td>12.1 - deleted NOTE 1.</td>
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<td></td>
<td>12.2 - clarified scoping for variable statements occurring inside a</td>
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<td><code>FunctionExpression</code>.</td>
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<td>12.6.4 - removed the initial part of the second last paragraph that</td>
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<td></td>
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<td>talked about the mechanics and order of enumeration of properties</td>
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<td>being implementation dependent. Added a clarification that newly added</td>
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<td>properties during enumeration are not visited in the active enumeration.</td>
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<td>15.3.4 - clarified the &quot;initial&quot; value of Function.prototype's</td>
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<td><code>[[Extensible]]</code> property.</td>
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<td>Removed all &quot;this&quot; coercion:</td>
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<td>15.3.4.3, 15.3.4.4 – both apply and call will no longer attempt to</td>
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<td>coerce &quot;this&quot; to an object, or to the global object.</td>
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<td>15.4.4.16 through 15.4.4.20 – the &quot;this&quot; parameter, if it is passed</td>
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<td>in, is used as-is to invoke the callback; if the this parameter is not</td>
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<td>passed in, <code>undefined</code> as used.</td>
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<td>C.1.1 - updated item 5 calling out removal of the this coercion.</td>
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<td>C.1.1 – fixed minor typo in item 8, updated item 11 calling out that</td>
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<td>deleting an unbound reference should throw in strict mode, fixed minor</td>
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<td>typo in item 14.</td>
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<td>Annex D - changed <code>[[class]]</code> to <code>[[Class]]</code> in the third paragraph</td>
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<td>Annex E - added a clarification regarding RegExps in the second</td>
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<td>paragraph.</td>
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<td>03 Nov 2008</td>
<td>pratapl.</td>
<td>15.5.4.21, 15.6.4.4, 15.7.4.8, 15.9.5.44 - fixed step 3 in the</td>
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<td>algorithms to test for <code>IsCallable(Result(2))</code>.</td>
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<td>13.2.1 - made &quot;this&quot; coercion logic conditional on the strictness of</td>
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<td>the function.</td>
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<td>15.3.4.5 - incorporated revised formulation for <code>Function.prototype.bind</code></td>
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<td></td>
<td></td>
<td>15.3.4.5.1, 15.3.4.5.2 - introduced <code>[[Call]]</code> and <code>[[Construct]]</code></td>
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<td>semantics for bind.</td>
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<td>15.4.4 - fixed a section reference to <code>[[ThrowablePut]]</code>.</td>
</tr>
</tbody>
</table>
15.4.5.1 - clarified own/inherited property usage in step 14.
15.12 - introduced JSON grammar.
15.12.1 - revised pseudo-code for JSON.parse
15.12.2 - revised pseudo-code for JSON.stringify

4.2.2 - changed section title to ‘The Strict Variant of ECMAScript’
10.3.2.1, 10.4.2.1, 11.4.1.1, 11.13.1.1, 11.13.2.1, 12.1.1, 12.6.4.1, 12.10.1,
15.1.2.1 - changed section title to ‘Strict Mode Restrictions’

11.3.1.1, 11.3.2.1, 11.4.4.1, 11.4.5.1 - deleted these sections on usage subset restriction.
13 - function bodies can now have a use strict directive.

Introduced the notion of Lexical Environments.
8.6.2 - renamed “scope chain” to “lexical environment” throughout the document starting from this point onwards.
8.7 - clarified the components of a “Reference” and their access (abstract operations).
8.7.1 - updated GetValue in terms of the revised abstract operations on References.
8.7.2 - PutValue no longer takes a ‘Throw’ parameter. Updated algorithm in terms of revised abstract operations on References.
10 - incorporated changes to the entire section to introduce the notion of Lexical Environments. Deleted 10.2.4 (Lexical Block Code).
11.2.3, 11.4.1, 11.4.3, 11.13.1.1, 11.13.2.1 - updated algorithm in terms of the revised abstract operations on References.
11.3.1, 11.3.2, 11.4.4, 11.4.5, 11.13.1 - updated algorithm in terms of revised PutValue.
12.2 - updated description for the VariableStatement, and the evaluation of the VariableDeclaration : Identifier Initialiser production.
12.10 - revised the algorithm in terms of the Lexical Environment and environment records.
12.14 - revised the algorithm in terms of the Lexical Environment and environment records. In ES3.1 this is the primary use case for the notion of lexical environments.
15.1.5.2 - added this subsection to call out JSON as a property on the Global Object.

Removed all mention of ConstantStatement
12, 12.15, A.4 - deleted all mention of ConstantStatement and relevant productions.

Introduced “debugger;“ as a statement form.
12, 12.15, A.4 - introduced DebuggerStatement.
15.3.2.1 - removed the second last step that was adding the “parameters” property. This property is no longer supported on function instances.
C.1.1 - removed mention of when an arguments property is initialized.
D - added mention of the swapping of steps in 11.2.3.

07 Nov 2008 - introduced this new section for the internal Same Value comparison function.
15.4.4.14, 15.4.4.15 - replaced ‘===’ comparison of searchElement with a call to the SameValue function.
15.9.4.2 - corrected minor spelling
15.12.1, 15.12.2 - added suitable notation to indicate optional arguments in the function signatures; replaced the test for type being “function” with IsCallable(); replaced check for the Class by actually testing the [[Class]] property.

10.3.3 - corrected minor spelling.
8.10.1, 8.10.2, 8.10.3, 8.10.4, 8.10.5, 10.2.2, 10.2.2.1, 10.2.2.2, 10.2.2.3, 10.2.2.4, 10.3.1, 10.3.2, 10.3.3, 15.5.4.14, 15.10.2.5, 15.10.2.6, 15.10.8.2, 15.10.2.15, 15.12.1, 15.12.2, 15.12.2 - Replaced inconsistent use (w.r.t. section 4.3.25) of “internal function” with “abstract operation” in relevant places.

15.2.3.3, 15.2.3.4, 15.2.3.8, 15.2.3.9, 15.2.3.10 - removed all mention of “the static”.
15.2.3.5, 15.2.3.6, 15.2.3.7 - renamed “method” to “function”.
15.2.4.5, 15.2.4.7 - updated algorithm to use [[GetOwnProperty]].

12.6.4 - mentioned that the property enumeration order is not specified, and deleted the sentence saying that the order of enumeration is defined by the object.

7.5.3 - moved ‘const’ back to the FutureReservedWords lists and added a note alluding to the future use of ‘const’, ‘let’, and ‘yield’.
8.11 - added this section as a place holder for the Environment Record Type.
9.11 - Moved SameValue algorithm here from 11.9.7.
12 - added a note regarding FunctionDeclaration within a SubStatement.
Annex C, D, E - added a note saying these need to be updated.
15.2.4.1 through 15.2.4.7 - All methods that make use of their ThisValue now account for the possibility that they are being invoked (via Function.prototype.apply or Function.prototype.call) with a non-object value passed as the thisArg.
15.2.4.3 – introduced pseudo-code for toLocaleString.

Incorporated updates for Decimal
7.8.3 - introduced DecimalLiteral, and clarified rounding in the case of Decimals.
8.5 - defined the Decimal Type (alongside the Number Type).
9.2 - defined ToDecimal conversion (alongside the ToNumber conversion).
9.3.1 - defined the ToDecimal conversion as applied to Strings (alongside the ToNumber conversion).
9.8.1 - defined the ToString conversion as applied to the Decimal Type (alongside the Number Type).
11.3.1, 11.3.2, 11.4.4, 11.4.5, 11.4.7, 11.6.1, 11.6.2, 11.9.3, 11.9.6, 15.1.2.4, 15.1.2.5 - explicitly call out the method (as defined in IEEE 754-2008) to apply.
11.8.1, 11.8.2, 11.8.3, 11.8.4 - removed special casing for Decimal.
11.8.5 - added step 21 for Decimal.
15.13.2.1 - introduced Decimal ( [value] )
15.13.3.1 - clarified semantics for the constructor.
15.13.4.1 through 15.13.4.9 - moved from the earlier sections 15.13.5.7 through 15.13.5.15.
Deleted getExponent (was section 15.13.4.5), reduce (was section 15.13.4.8), quantize (was section 15.13.4.9), roundingMode (was section 15.13.5.3).
Introduced rescale (now section 15.13.4.15).

Regenerated TOC